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345 Courtland Street, NE
Atlanta, GA 30365

EPA 904/9-83-108c
June 1983

EPA

Environmental Impact Statement

Draft

North Carolina Barrier Islands Wastewater Management

Technical Reference Document Alternatives Development Report

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North Carolina Barrier Islands Environmental Impact Statement

Technical Reference Document

Alternatives Development Report

September 1982

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METRIC CONVERSION CHART

1 inch (in.) = 2.54 centimeter (cm)	1 cm = 0.394 in.
1 foot (ft) = 0.305 meter (m)	1 m = 3.28 ft
1 mile (mi) = 1.61 kilometer (km)	1 km = 0.621 mi
1 square foot (ft^2) = 0.0929 square meter (m^2)	1 m^2 = 10.76 ft^2
1 acre (ac) = 0.405 hectare (ha)	1 ha = 2.47 ac
1 gallon (gal) = 3.79 liter (l)	1 l = 0.264 gal
1 million gallons per day (mgd) = 3,790 m^3/d	1 m^3/d = 0.000264 mgd
degrees F = 1.8 °C + 32	degrees C = (°F - 32)(.555)

1.0 INTRODUCTION

ENVIRONMENTAL, ECONOMIC AND FISCAL CONCERNS LEAD EPA TO A GENERIC STUDY OF FIVE BARRIER ISLAND 201 PLANS

Concern for several key issues led EPA to undertake a generic Environmental Impact Statement for five North Carolina barrier island 201 plans. Key concerns include: impacts on surface and groundwater, possible alternative management technologies, economic and fiscal impacts on local citizens and governments, potential impacts on sensitive natural areas, potential for storm damage to treatment systems and nonpoint source pollution.

Presently six 201 Facilities Plans which include barrier islands have been submitted to EPA for approval. These plans are Southwestern Brunswick County, Southeastern Brunswick County, Topsail/Surf City in Onslow County, Carteret County Complex, Hatteras Island and Dare Beaches Complex in Dare County. Figure 1.0 shows the location of these planning areas.

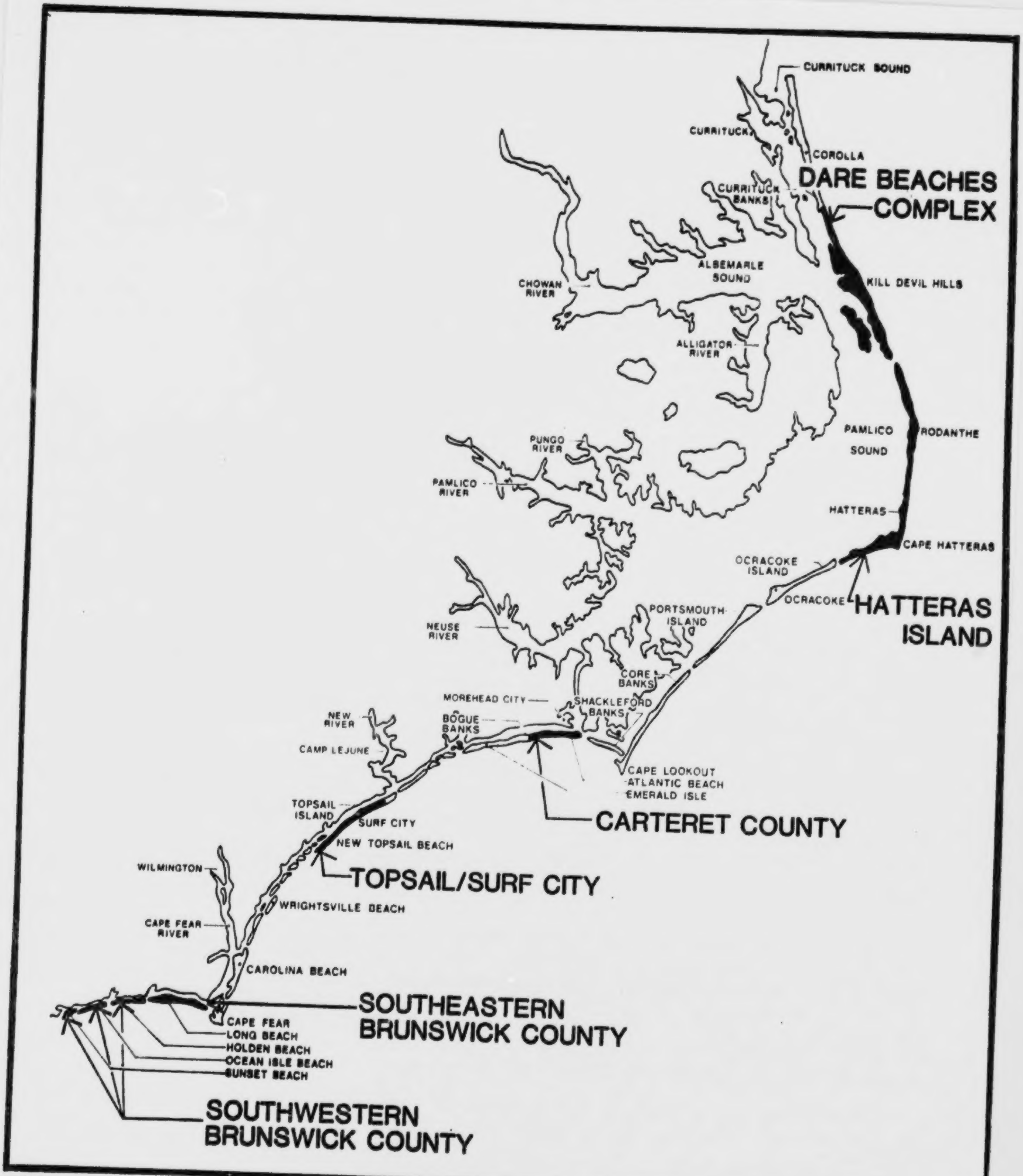
EPA funding for proposed facilities has been determined to be a major Federal Action significantly affecting the quality of the human environment, and therefore, the National Environmental Policy Act (NEPA) requires that an EIS be prepared. A generic EIS is the most expeditious way of addressing the issues identified below and making the proper decisions about the 201 Plans now awaiting action. In addition, the preparation of a generic EIS will result in a consistent regional approach in EPA's decisions on funding of wastewater treatment facilities for the North Carolina barrier islands.

In order to assure consistent actions predicated on the most complete available data, the geographical area considered in the North Carolina Barrier Islands EIS extends over 300 miles from Currituck Banks at the Virginia/North Carolina border to Sunset Beach at the South Carolina/North Carolina border. The 201 Facilities Plans under consideration within this area cover about 40 percent of the length of the barrier islands along the state's coast.

Five of the draft 201 Facilities Plans received by EPA propose the construction of wastewater collection, transportation and treatment facilities to serve large portions of these islands. After an environmental review of the proposed facilities plans, EPA had significant concerns about the potential impacts of these plans. The sixth study, the Hatteras Island 201 Plan, concluded that centralized wastewater management systems would not be cost-effective during the 1980's and recommended no action.

Several key issues led to the decision to conduct this EIS for the North Carolina barrier islands. These issues are:

- Surface water and groundwater quality impacts
- Alternative wastewater management technologies
- Economic and fiscal impacts on local citizens and governments
- Sensitive natural areas
- Potential for storm damage
- Nonpoint source pollution


CURRITUCK SOUND
CURRITUCK
COROLLA
DARE BEACHES COMPLEX
CURRITUCK BANKS
ALBEMARLE SOUND
CHOWAN RIVER
KILL DEVIL HILLS
ALLIGATOR RIVER
PAMLICO SOUND
RODANTHE
PUNGO RIVER
PAMLICO RIVER
HATTERAS
CAPE HATTERAS
OCRACOKE ISLAND
OCRACOKE
HATTERAS ISLAND
PORTSMOUTH ISLAND
NEUSE RIVER
CORE BANKS
MOREHEAD CITY
SHACKLEFORD BANKS
NEW RIVER
BOGUE BANKS
CAMP LEJUNE
CAPE LOOKOUT
ATLANTIC BEACH
EMERALD ISLE
CARTERET COUNTY
TOPSAIL ISLAND
SURF CITY
NEW TOPSAIL BEACH
TOPSAIL/SURF CITY
WILMINGTON
WRIGHTSVILLE BEACH
CAPE FEAR RIVER
CAROLINA BEACH
SOUTHEASTERN BRUNSWICK COUNTY
CAPE FEAR
LONG BEACH
HOLDEN BEACH
OCEAN ISLE BEACH
SUNSET BEACH
SOUTHWESTERN BRUNSWICK COUNTY

LEGEND

Figure 1.0 Barrier Islands Within 201 Facilities Plan Study Areas

BARRIER ISLANDS E.I.S.
U.S. ENVIRONMENTAL PROTECTION AGENCY
REGION IV

Prepared by:
CLAUDE TERRY & ASSOCIATES, INC. ATLANTA, GA.
GANNETT FLEMING CORDDRY AND CARPENTER, INC.

SCALE IN MILES
5 2.5 0 5 10 15 20 30 40

PAG

1.0 Continued

Surface and Groundwater Quality

There is a need to identify existing areas of water pollution and the sources of that pollution. The draft 201 Plans endeavored to justify the need for wastewater facilities on the barrier islands based on the pollution of shellfishing waters by failing septic tanks. Analysis of the data does not appear to support this position except in a few cases.

Pollution on barrier islands could involve surface waters, either fresh or estuarine, or groundwater. Sources of pollution may be septic tank failure, sewage plant discharges, runoff from developed areas, migratory waterfowl, and discharges from vessels' sanitary facilities.

Alternative Wastewater Management Technologies

Significant changes have occurred between the onset of the EPA 201 program in 1975 and today. One major shift in viewpoint is the acceptance of the permanency and usefulness of various on-site and small (<379 m^3/d) (<100,000 gpd) community systems. Initial 201 efforts focused on large regional plants as the answer to sewage treatment needs. This emphasis was properly placed for large urban areas. By 1978, EPA had rethought its approach and formally suggested that septic tanks and other on-site devices could serve as permanent treatment systems in some areas, given proper management.

While some septic tank failures are known and documented on the barrier islands, many areas have been served by septic tanks for years without problems. EPA has not only accepted functioning septic tanks and other on-site systems as permanent but may consider such alternative systems innovative and allow higher federal funding percentages than for conventional regional systems. EPA now recognizes that regional systems may have significant adverse primary and secondary environmental impacts. Due to their nature, barrier islands could be more than ordinarily susceptible to these impacts.

Economic and Fiscal Impacts on Local Citizens and Governments

The significant seasonal and day use of barrier islands may lead to large financial impacts for citizens of small communities, who may find themselves providing funding for plant capacity which is needed only a few days per year.

Sensitive Natural Areas and Potential for Storm Damage

Barrier islands have special environmental characteristics which enhance both their value and their vulnerability. These attributes include:

- High direct exposure to the Atlantic Ocean and its storms
- Vulnerability to overwash, inlet formation and erosion or deposition
- Vulnerability of vegetation to wind-borne salt spray
- Salt marshes and freshwater marshes

- Sand dunes as part of a sand sharing system
- Maritime forests
- Fresh water existing as a lens and subject to surface pollution or salt water intrusion.

A number of ecological niches have evolved on barrier islands which are infrequently encountered elsewhere and may be quite sensitive to disturbance. Similarly, the physical structures are often fragile and easily damaged by human uses and abuses. These attributes led to extensive state concern and legislation which EPA will consider in alternatives development. Specific 201-related potential problems which merit individual study include:

- Sewer disruption by erosion/inlet formation
- Damage to sewage plants by storms
- Aquifer pollution by faulty septic tanks or by nonpoint runoff
- Disruption of Areas of Environmental Concern* as a direct or indirect consequence of 201-derived actions
- Pollution of shellfish beds by point or nonpoint discharges
- Disruption of wildlife habitat areas
- Destruction of threatened or endangered species or their habitats.

Nonpoint Source Pollution

The provision of new wastewater management systems, particularly central or regional treatment plants, may promote higher density development, thus increasing the potential for nonpoint source pollution of estuarine waters.

Summary

These considerations were of sufficient significance to lead EPA to undertake this study. A wastewater management strategy developed herein provides an alternative to either implementing the 201 plans as written or undertaking no federal action.

---

*Environmentally sensitive areas delineated by the N.C. Coastal Zone Management Program requiring special protection and management.

1.0 INTRODUCTION

1.1 Purpose of Report

REPORT DESCRIBES AND EVALUATES REASONABLE ALTERNATIVE STRATEGIES FOR PREPARING WASTEWATER MANAGEMENT PLANS

The Alternatives Development Report is intended to establish reasonable alternative strategies for wastewater management plans covering North Carolina barrier islands. These strategies present three approaches to the planning process used to select appropriate treatment facilities.

The purpose of the Alternatives Development Report is to identify, describe and evaluate the potential planning procedures that could be used to develop cost-effective wastewater management plans for barrier islands located in North Carolina. In this generic EIS three potential strategies appear to offer genuine alternative approaches to planning for wastewater management on the North Carolina barrier islands. These alternative strategies are:

- The 201 strategy - under this approach, the proposed 201 Plans would be accepted as is, and implementation would proceed.
- The EIS strategy - the bulk of this report deals with development of modifications to the traditional 201 planning procedures and technologies to be considered for North Carolina barrier islands.
- The No Federal Action strategy - under this strategy there would be no further expenditure of federal funds for development or implementation of 201 plans on North Carolina barrier islands. Implementation would be carried out at local expense.

EXTENSIVE USE OF SYSTEM FLOWCHARTS CLARIFIES PROCEDURES

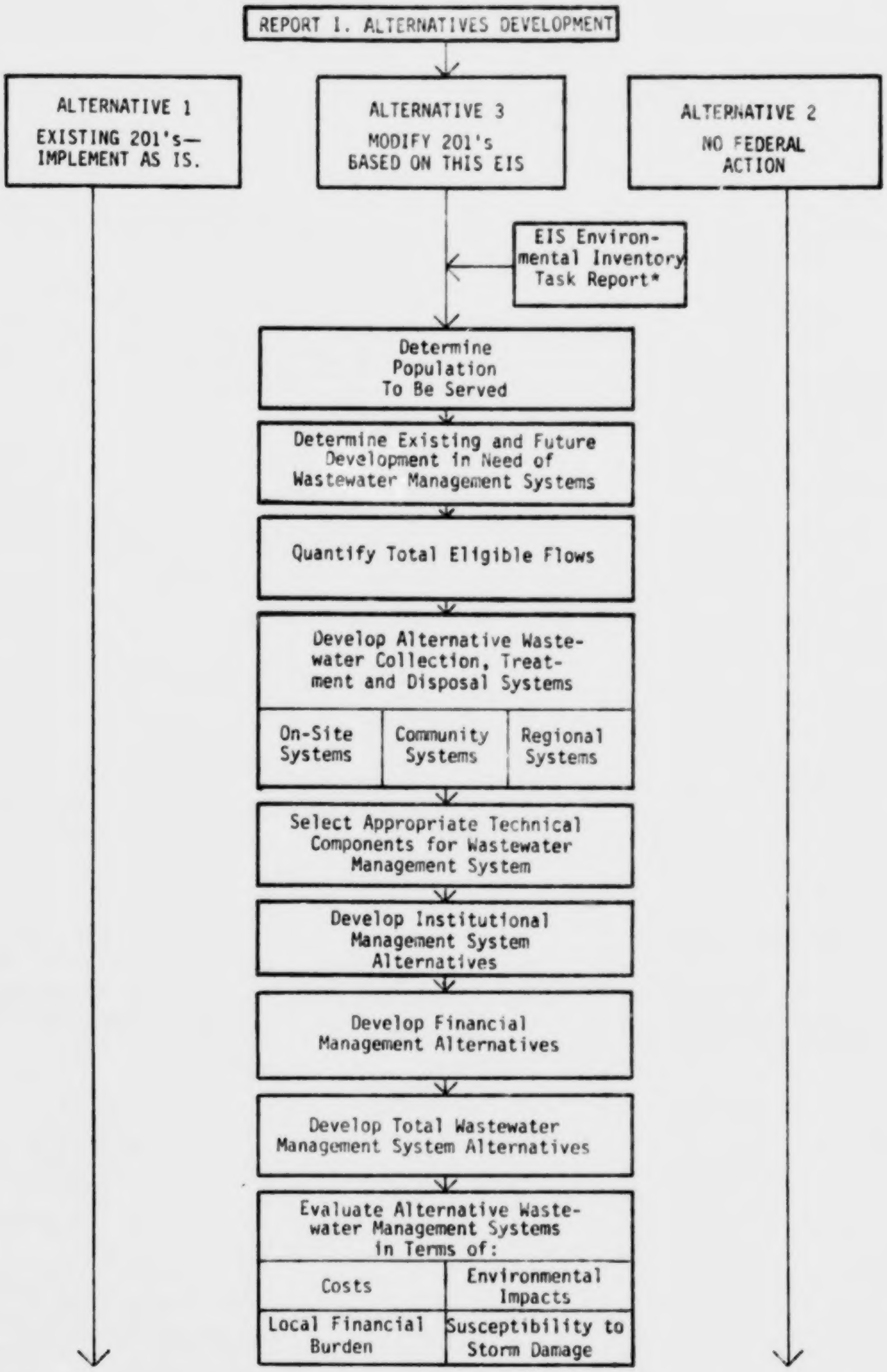
The Alternatives Development Report identifies and compares the differences between 201 planning, modified 201 planning, and No Federal Action. The text of the report defines the three strategies through verbal and graphic descriptions.

The Alternatives Development report is designed to provide detailed information in a highly useable format. The report starts with an introduction in Chapter 1.0. Chapter 2.0 provides a description of the 201 Alternative, including individual 201 Plans and their technical, financial and institutional components. Chapter 3.0 describes the No Federal Action Alternative, which includes a projection of future wastewater management technologies and financial and institutional management arrangements which could be expected to be implemented in the absence of federal funding.

Chapter 4.0, the major portion of this report, suggests procedures which could be used in developing and modifying local 201 Plans for barrier islands. The procedures acknowledge the special characteristics of the barrier islands and address them as they present special problems or opportunities for systems development or management. In preparing Chapter 4.0, systems flowcharts of procedures were first developed, then narratives were written to support the graphics.

Figure 1.2 represents the Alternatives Development report organization in graphic form. An effort is made to distinguish between descriptive material and procedural material.

The STOP format is used throughout this report. Material to be presented is broken down into small individual units and arranged in a heirarchy under topical headings. The narrative of each unit is generally supported by a graphic. The narrative is preceeded by an information headline and an abstract of the material presented. The greatest advantage of STOP format is that a reviewer may read the report on any one of three levels of detail: the headlines, the headlines and abstracts, or the headlines/abstracts/narratives.


REPORT I. ALTERNATIVES DEVELOPMENT
ALTERNATIVE 1
EXISTING 201's— IMPLEMENT AS IS.
ALTERNATIVE 3
MODIFY 201's BASED ON THIS EIS
ALTERNATIVE 2
NO FEDERAL ACTION
EIS Environmental Inventory Task Report*
Determine Population To Be Served
Determine Existing and Future Development in Need of Wastewater Management Systems
Quantify Total Eligible Flows
Develop Alternative Wastewater Collection, Treatment and Disposal Systems
On-Site Systems
Community Systems
Regional Systems
Select Appropriate Technical Components for Wastewater Management System
Develop Institutional Management System Alternatives
Develop Financial Management Alternatives
Develop Total Wastewater Management System Alternatives
Evaluate Alternative Wastewater Management Systems in Terms of:
Costs
Environmental Impacts
Local Financial Burden
Susceptibility to Storm Damage

*Published separately October 1982 as a Technical Reference Document

Figure 1.2. Organization of Alternatives Development Report.

Source: Claude Terry & Associates, Inc. 1981

1.0 INTRODUCTION
1.3 Definition of Key Terms

REGIONAL, CENTRAL, COMMUNITY AND INDIVIDUAL SYSTEMS ARE DEFINED

Definitions are based on the area to be served and not on system components and their size.

Throughout the task report, wastewater treatment systems are characterized as regional, central, community or individual. Each of these terms is premised upon the involvement of political jurisdictions in a treatment system and not upon the type or scale of technical components. The four terms are defined below:

Regional System

A regional system is one in which two or more political jurisdictions collaborate on a technical solution to wastewater management problems. A regional system may be any size in terms of m^3d or mgd.

Central System

A central system is one in which a single wastewater facility serves a single political jurisdiction in its entirety.

Community System

A community system is one which serves an area within a political jurisdiction. Small community systems tend to serve a subdivision or a neighborhood.

Individual System

An individual system is one in which a single building lot is served by a single system. Typically such systems are on-site soil absorption systems serving a single residence, multifamily unit or small commercial enterprise.

2.0 DESCRIPTION OF THE 201 ALTERNATIVE

201 FACILITIES PLANS PROVIDE VEHICLE FOR IMPROVING WATER QUALITY

The planning procedure provided by the 201 Facilities Plan Step 1 regulations offers general guidance to local jurisdictions with water quality problems. Cost-effective, environmentally sound solutions to these problems ultimately depend upon the site specific knowledge of the local officials participating in the wastewater facility selection process.

Coastal communities interested in solving water pollution problems within their boundaries may apply for federal monetary assistance to evaluate the extent of water quality degradation. North Carolina has designated several planning areas along the coast, including barrier islands. These individual areas were identified to allow the assessment of a full range of wastewater treatment options.

The local units of government within a planning area joined together to prepare a 201 Facilities Plan in accordance with the regulations governing the Clean Water Act (Federal Water Pollution Control Act as amended). The facilities plan provided a master plan for wastewater collection, treatment, and disposal for a 20-year planning period. Procedures developed for drafting the facilities plan follow a logical sequence and lead to the identification of the most cost effective and environmentally sound technical solution for the particular study area. To accomplish this investigation ten steps are followed:

- Identify the water quality problem
- Establish effluent limitations
- Investigate the environment within the study area
- Describe the existing physical, economic and social structure
- Predict future trends for a 20 year period
- Identify potential wastewater treatment systems
- Evaluate potential wastewater treatment systems
- Select the most appropriate system
- Determine institutional and financial needs for project implementation
- Obtain state and federal plan approval

The results of this procedure may range from a decision to retain present wastewater treatment facilities to a commitment to develop a new system that is based on cooperation among several units of government experiencing problems that cannot be solved by the individual entities.

The rules and regulations governing the 201 Facilities Plan are written to address problems common to all jurisdictions. The guidance provided is often not site specific and may require that the units of government consider the unique attributes of their jurisdictions in addition to meeting the requirements of the rules and regulations. In the case of the plans prepared for North Carolina's barrier islands, special attention is needed to address the unique environmental attributes of the islands and the socioeconomic questions surrounding a seasonally dependent economy.

Upon completion of an approved 201 Facilities Plan, the participating governments may proceed with the design (Step 2) and building (Step 3) of the proposed facilities. The Municipal Wastewater Treatment Construction Grant Amendments of 1981 (PL 97-117), which revised the regulation governing grants, allow for federal funding to continue for combined design and building grants (Step 2-3 grants). The design segment grant eligibility is to be determined using the allowance system with the amount being based on the estimated Step 3 allowable building costs. The allowance ranges from 7.253 percent of a $100,000 building cost to 4.656 percent of a $100 million building cost. The building segment federal share will continue to be 75 percent for grant assistance awarded before October 1, 1984, and then reduced to 55 percent for grant assistance awarded for initial building phases or segments awarded after September 30, 1984.

The non-federal project costs can be partially funded by the state government which in turn receives an allotment specified by Congress each fiscal year. Local governments may apply to the State for 50 percent of the non-federal share. Funds become available based on a priority ranking system established by the State. Once the particular project reaches the top of the list, funds are granted and the plan is implemented. Sometimes it is necessary for the local units of government to fund certain portions of the facilities without the benefit of federal dollars. These elements should be identified during the planning procedures.

In summary, the 201 Facilities Plan provides a mechanism to local jurisdictions that assists in identifying, assessing, and developing solutions to water quality problems affecting their community.

2.0 DESCRIPTION OF THE 201 ALTERNATIVE

2.1 Individual Plans

SIX 201 PLANS PROPOSE CENTRALIZED WASTEWATER COLLECTION AND TREATMENT FACILITIES

The 201 plans covering North Carolina's barrier islands propose centralized treatment systems to alleviate water pollution from septic systems, improve shellfishing and allow for anticipated growth.

Six 201 Wastewater Facilities Plans that include barrier island locations along the North Carolina coast are currently pending. These 201 plans address Southwestern Brunswick County, Southeastern Brunswick County, Topsail/Surf City, the Carteret County Complex, Hatteras Island and Dare Beaches Complex in Dare County. Each plan was prepared during the late 1970's to address the need for wastewater facilities during the 20-year planning period. Increasing acreages of closed shellfish waters, combined with localized septic tank failures and expected development pressures, were problems submitted by local governments as justification for building sewage treatment facilities. In each case the selected alternative was a wastewater collection and treatment facility that would remove the need for further use of on-site treatment systems.

Cost figures were taken from each draft plan and included in the following sections of Chapter 2.0. The cost figures for the plans are not comparable since each plan evaluates different cost elements. Debt service is sometimes expressed as strictly the local share and other times as the full interest costs as if there were no federal or state grants (which are interest-free).

The following sections describe the technical, financial and institutional components of each 201 plan. Thereafter, each of these three components is summarized in order to present an overview of wastewater management on the barrier islands if the 201 plans were implemented as presently proposed.

2.0 DESCRIPTION OF THE 201 ALTERNATIVE

2.1 Individual Plans

2.1.1 Southwestern Brunswick County 201 Plan

A CENTRALIZED TREATMENT SYSTEM IS PROPOSED FOR EACH OF FIVE COMMUNITIES

The selected alternative includes construction of five separate collection systems, secondary treatment facilities and sites for land application by spray irrigation. These individual systems will serve the towns of Calabash, Sunset Beach, Holden Beach, Ocean Isle Beach and Shallotte. Each community will be responsible for funding its portion of the treatment facility and arranging the total funding of the collection system. In addition each town will provide system management, operation and maintenance.

Technical Aspects

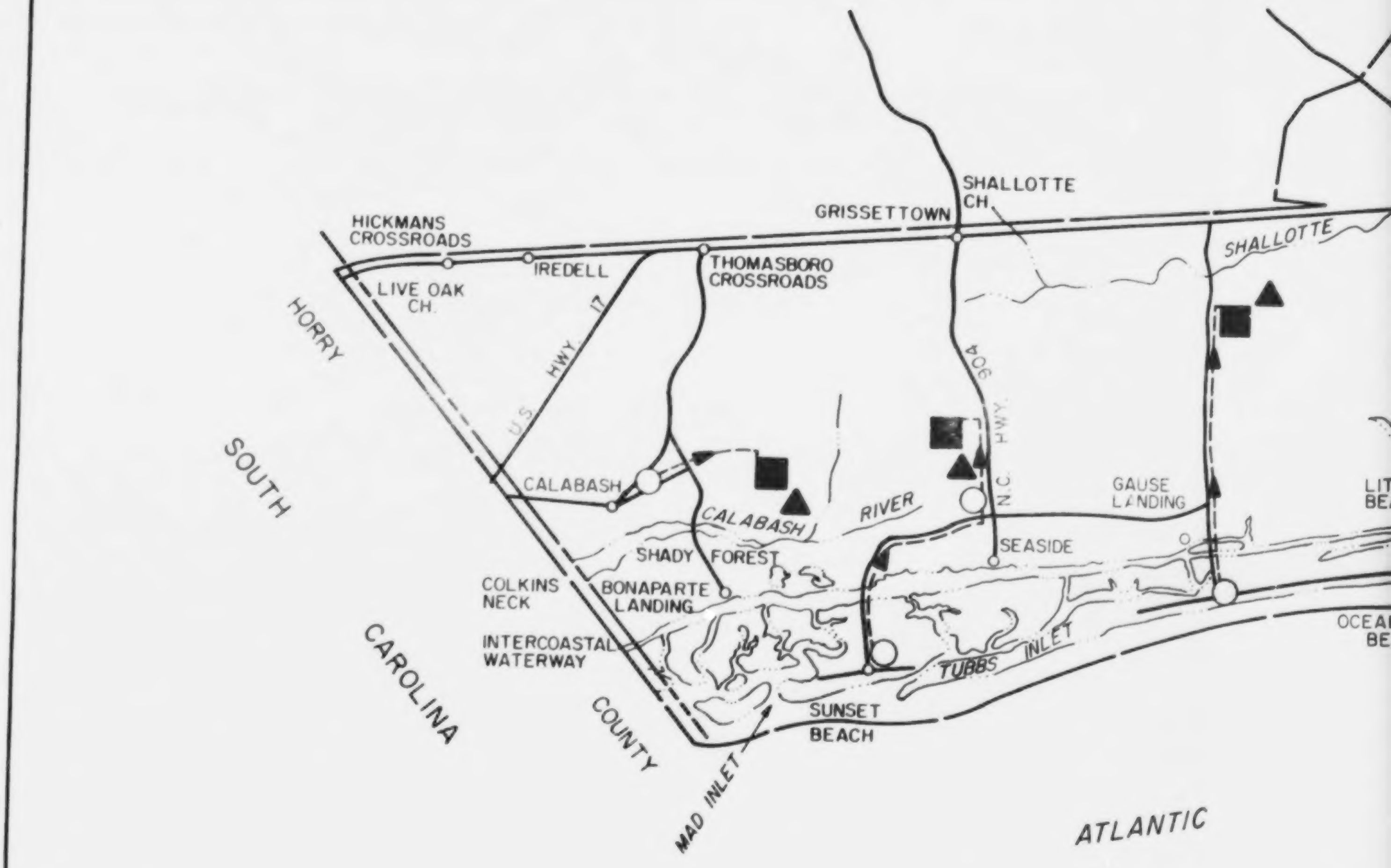
The proposed alternative includes five separate collection/interceptor systems, treatment plants, lagoon systems and sites for land application by a solid set spray irrigation system. Figure 2.1.1 is a map showing the location of these systems. Each town's collected wastewater flows will flow to the town's main pump station. From there they will flow to the lagoon system which will provide secondary treatment. The lagoon system includes coarse screening facilities (prior to lagoon), a lagoon and chlorination facilities. The lagoon effluent is chlorinated prior to land application. The 201 Facilities Plan stated that due to the nature of the treatment process, daily sludge handling and disposal will not be required. Generally, the sites selected for land application are located in rural areas that are forested and/or undeveloped land.

Costs for the three systems located on barrier islands are presented in Table 2.1.1. These costs are those presented in the draft 201 Plan prepared in 1979 and have not been updated. These figures do not include the cost for a collection system.

Table 2.1.1 Estimated Project Capital Costs and Annual Local Costs for Southwestern Brunswick County.

	Ocean Isle Beach	Holden Beach	Sunset Beach
Pump Station	$118,897	$118,987	$95,266
Force Main	154,277	268,931	132,164
Pretreatment	453,162	572,621	--
Land Application	282,645	285,897	478,693
Land Acquisition	110,500	116,500	55,500
Total	$1,119,481	$1,362,936	$761,623
Local Annual O&M	$30,886	$30,917	$25,144
Local Annual Debt Service	8,225	10,305	3,824
Total Local Annual Cost	$39,141	$41,222	$28,968

Source: Pierson and Whitman, Inc. 1979. Southwest Brunswick County 201 Facilities Plan.


HICKMANS CROSSROADS
IREDELL
LIVE OAK CH.
THOMASBORO CROSSROADS
GRISSETTOWN
SHALLOTTE CH.
SHALLOTTE
HORRY
SOUTH
CAROLINA
COUNTY
U.S. HWY. 17
N.C. HWY. 904
CALABASH
CALABASH RIVER
SHADY FOREST
GAUSE LANDING
SEASIDE
COLKINS NECK
BONAPARTE LANDING
INTERCOASTAL WATERWAY
TUBBS INLET
SUNSET BEACH
MAD INLET
ATLANTIC
LIT
BE
OCEA
BE

LEGEND

▭ SEWAGE SERVICE DISTRICT

— — 201 FACILITIES PLANNING AREA BOUNDARY

- - - - MAJOR FORCE MAIN

■ WASTEWATER TREATMENT FACILITY

○ PUMPING STATION

▲ LAND APPLICATION SITES

BARRIER ISLANDS E.I.S.

U.S. ENVIRONMENTAL PROTECTION AGENCY
REGION IV

Prepared
CLAUDE
GANNET

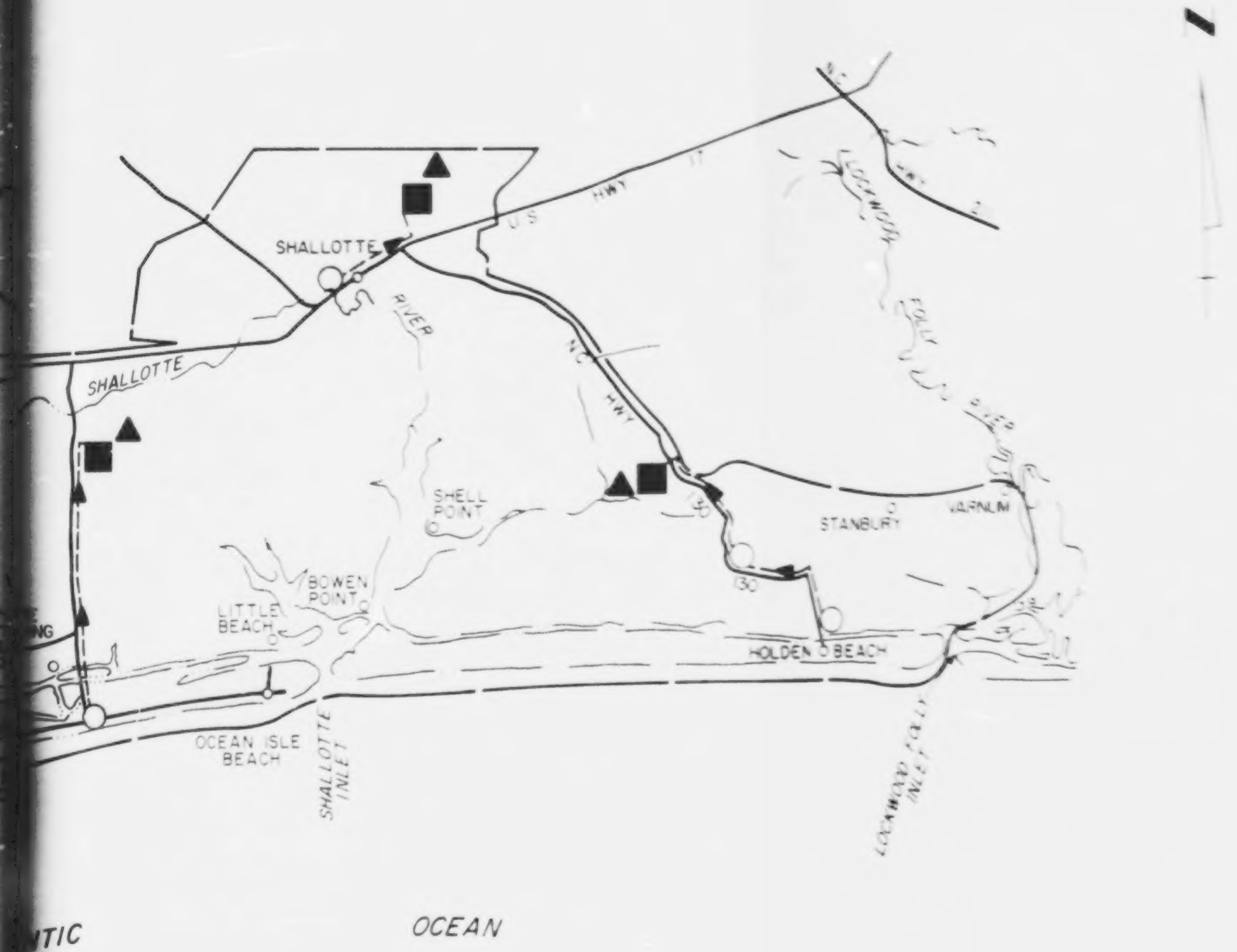
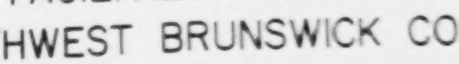

N
NC
US HWY 17
LOCKWOOD FOLLY RIVER
NC HWY 211
SHALLOTTE
SHALLOTTE RIVER
NC HWY 130
SHELL POINT
STANBURY
VARNUM
BOWEN POINT
LITTLE BEACH
130
130
179
HOLDEN BEACH
OCEAN ISLE BEACH
SHALLOTTE INLET
LOCKWOOD FOLLY INLET
NTIC
OCEAN

Figure 2.1.1

REGIONAL ALTERNATIVE PLAN
FIVE LOCAL TREATMENT FACILITIES WITH
LAND APPLICATION SITES FOR
SPRAY IRRIGATION OF EFFLUENT

201 FACILITIES PLANNING AREA
SOUTHWEST BRUNSWICK COUNTY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2
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4
SCALE IN MILES

E.I.S.

Prepared by:
CLAUDE TERRY & ASSOCIATES, INC. ATLANTA, GA.
GANNETT FLEMING CORDDRY AND CARPENTER, INC.

2.1.1 Continued

Financial Aspects

The proposed treatment facilities may be eligible for funding on a matching basis by EPA (75 percent), the state (12.5 percent) and local sources (12.5 percent). Facilities eligible for these funds include the pump stations, force mains and treatment works. Funds for each community's collection system may be obtained as grants or loans from the State Clean Water Bond Act or the Farmers Home Administration.

Each local government will be responsible for generating revenue to pay for both its share of construction costs and the total operation and maintenance costs. Construction costs may be met through sewer bond issues and system connection fees. User fees will be instituted to cover the operation and maintenance costs.

The individual communities will also act as the fiscal agency responsible for contract management, grant/loan administration and all other tasks involved in administering the design, construction and management of the proposed facilities.

Each town will also establish a Cost Recovery Ordinance consistent with state and federal funding requirements. Fees will include the following categories:

- Charge for treatment of sewage volume
- Charge for sewer system connection
- Charge for treatment of excessive polluting subsystems.

Institutional Aspects

A management plan for the proposed system is the responsibility of the towns. The 201 Plans do not yet include an ordinance to control the amount and quality of effluent put into the system, an ordinance to establish a rate structure to ensure adequate funding for the system construction and operation or a statement of the town's rights to review and approve facilities operations and staffing requirements. The 201 Plan did not address the possibility of instituting an ordinance that would require abandonment of existing septic systems if and when the new sewage plan is implemented.

FINANCIAL AND MANAGEMENT ARRANGEMENTS FOR PROPOSED WASTEWATER FACILITIES HAVE NOT BEEN IDENTIFIED

The regional wastewater treatment system proposed involves barrier island and mainland communities connected by collection and transmission facilities. Although several jurisdictions are involved, proposed institutional arrangements for funding, operating and managing the system have not been developed.

Technical Aspects

The 201 Facilities Plan for the Southeastern Brunswick County planning area proposed extending the existing collection system which presently serves only the town of Southport to include parts of Oak Island and some rural areas outside of Southport's boundaries. The new systems proposed will include the Oak Island communities of Long Beach, Yaupon Beach, Caswell Beach, and portions of unincorporated rural areas in Brunswick County.The regional treatment facilities would be located on a 10 ha (25 ac) site near Southport and would provide secondary treatment for a design flow of 7,845 m^3/d (2.07 mgd). The location of these facilities is shown in Figure 2.1.2.

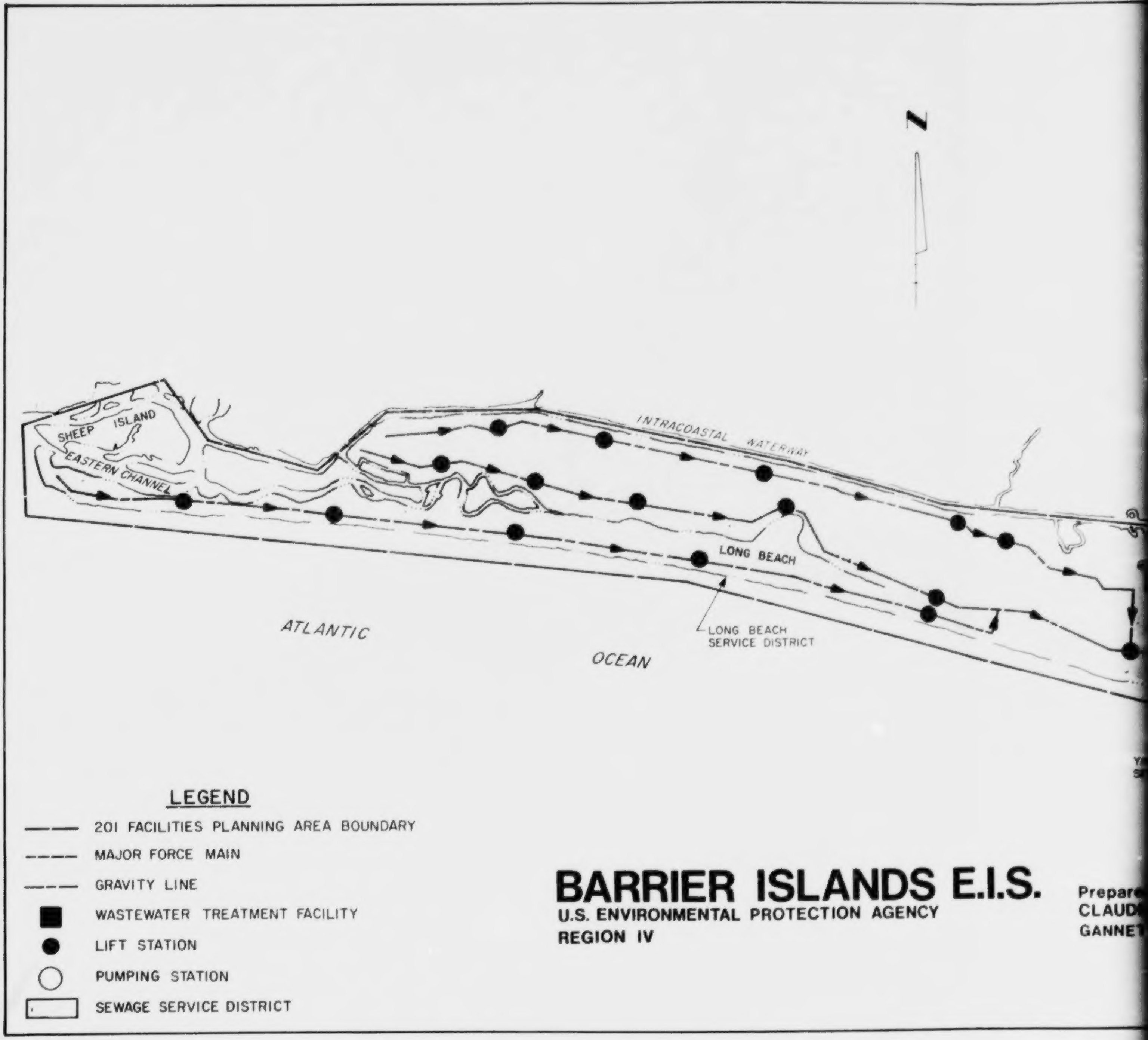
The collection/interceptor system is proposed to service areas that were identified as having a need based on projected development for 1990. The interceptor system that would transport the collected wastewater flows would include force mains with a system of lift stations and pump stations.

The proposed treatment facilities would consist of an oxidation ditch treatment process that provides secondary treatment. The existing secondary treatment facilities serving Southport would be abandoned. The treated effluent would then be discharged to the Cape Fear River.

1980 costs for the proposed treatment project as indicated in the 201 Plan are presented in Table 2.1.2. Costs associated with the collection and transmission portions are not eligible for EPA funding.

Financial Aspects

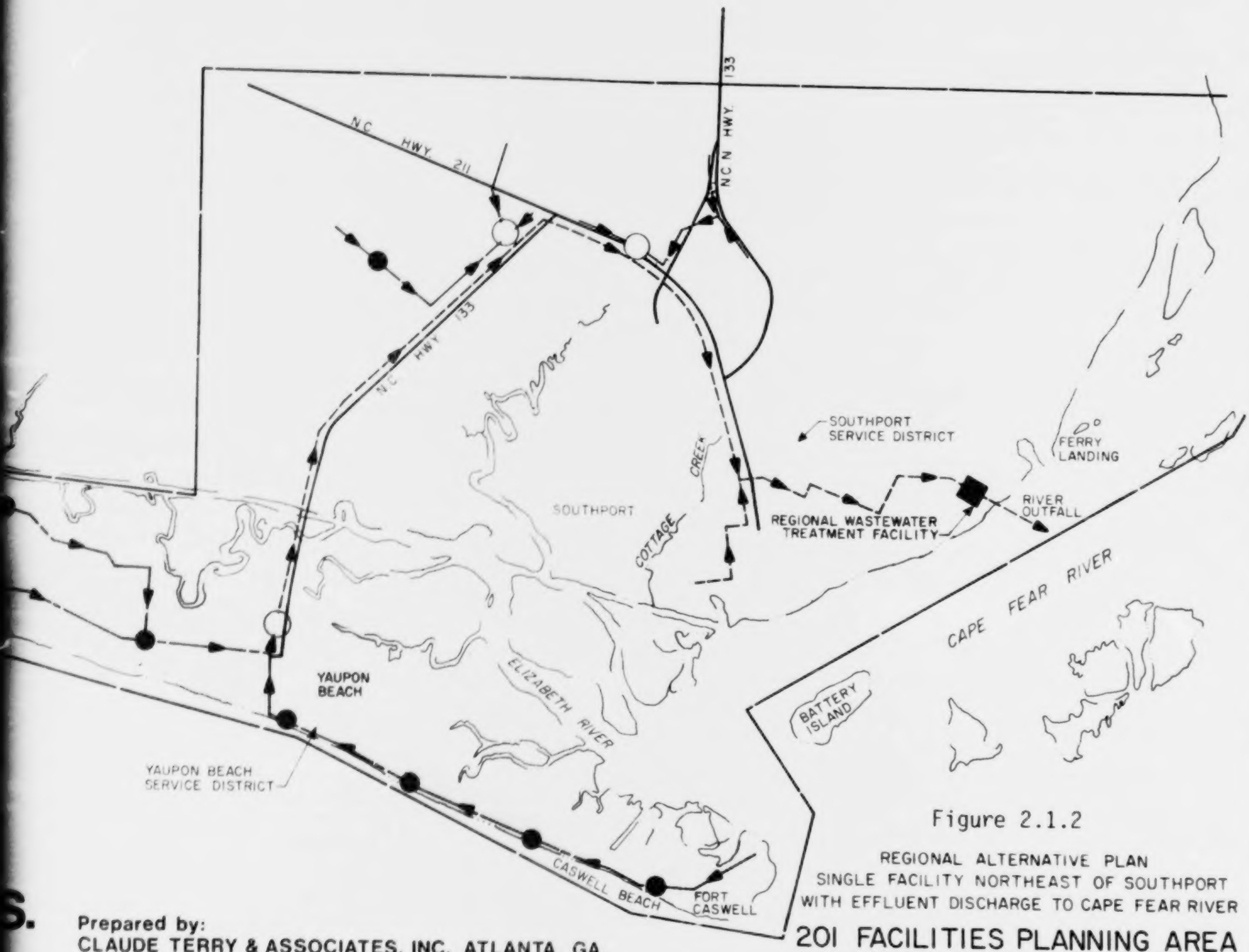
The 201 Plan indicates that federal and state funds will be used when available to fund a large portion of the treatment system (75 percent federal, 12.5 percent state) with the local governments providing the remainder. No discussion is presented about the mechanism to be used to generate local matching funds or to fund collection and transmission systems.


N
SHEEP ISLAND
EASTERN CHANNEL
INTRACOASTAL WATERWAY
LONG BEACH
LONG BEACH SERVICE DISTRICT
ATLANTIC
OCEAN
LEGEND
201 FACILITIES PLANNING AREA BOUNDARY
MAJOR FORCE MAIN
GRAVITY LINE
■ WASTEWATER TREATMENT FACILITY
● LIFT STATION
○ PUMPING STATION
▭ SEWAGE SERVICE DISTRICT

BARRIER ISLANDS E.I.S.

U.S. ENVIRONMENTAL PROTECTION AGENCY
REGION IV

Prepare
CLAUD
GANNET


NC HWY 211
NC N HWY 133
NC HWY 133
SOUTHPORT SERVICE DISTRICT
FERRY LANDING
SOUTHPORT
COTTAGE CREEK
REGIONAL WASTEWATER TREATMENT FACILITY
RIVER OUTFALL
CAPE FEAR RIVER
BATTERY ISLAND
YAUPON BEACH
ELIZABETH RIVER
YAUPON BEACH SERVICE DISTRICT
CASWELL BEACH
FORT CASWELL

S.

Prepared by:
CLAUDE TERRY & ASSOCIATES, INC. ATLANTA, GA.
GANNETT FLEMING CORDDRY AND CARPENTER, INC.

Figure 2.1.2

REGIONAL ALTERNATIVE PLAN
SINGLE FACILITY NORTHEAST OF SOUTHPORT
WITH EFFLUENT DISCHARGE TO CAPE FEAR RIVER

201 FACILITIES PLANNING AREA SOUTHEASTERN BRUNSWICK COUNTY

4,000 0 4,000 8,000
SCALE IN FEET

2.1.2 Continued

Table 2.1.2 Estimated Project Capital Costs and Annual Local Costs for Southeastern Brunswick County.

Collection System	$3,752,000
Transmission System	9,985,000
Treatment System	5,763,000
Total Capital Cost	$19,500,000
Local Annual Debt Service	$1,410,000
Local Annual O & M	$314,000
Total Local Annual Cost	$1,724,000

*Total annual debt service costs is for the total project and does not reflect federal and state grants covering 87.5 percent of eligible costs.

Source: Consoer, Townsend and Associates. 1978. Southeastern Brunswick County Facilities Plan.

Institutional Aspects

The 201 Plan does not address the institutional mechanisms necessary for coordinating the management of the collection and treatment facilities proposed.

2.0 DESCRIPTION OF THE 201 ALTERNATIVE
2.1 Individual Plans
2.1.3 Topsail/Surf City 201 Plan

PROPOSED PLAN DETAILS STRUCTURAL AND FINANCIAL ELEMENTS; INSTITUTIONAL ARRANGEMENTS REMAIN UNDECIDED

The selected plan includes a 8,717 m^3/d (2.3 mgd) collection/interceptor system to service Topsail Island. The treatment facilities would be located on the mainland west of Holly Ridge and would include a stabilization lagoon and spray irrigation system. Project costs are primarily covered by federal funds with local funds derived from user charges and general obligation bonds. Management and operations arrangements have not been finalized, but a regional authority appears to be the most probable solution.

Technical Aspects

The preliminary design of the system consists of a series of gravity sewer subsystems which would run in a linear fashion along the oceanfront. The sewer systems would have a complementary interceptor system consisting of pump stations and force mains necessary to pump the collected wastewaters to the treatment facilities west of Holly Ridge. The interceptor system would include the construction of a subaqueous force main to serve as a waterway crossing to transport flows from Topsail Island to the mainland. The installation of this crossing would be located adjacent to the existing highway (N.C. Route 50-210) bridge at Surf City. Figure 2.1.3 is a map showing the location of these facilities.

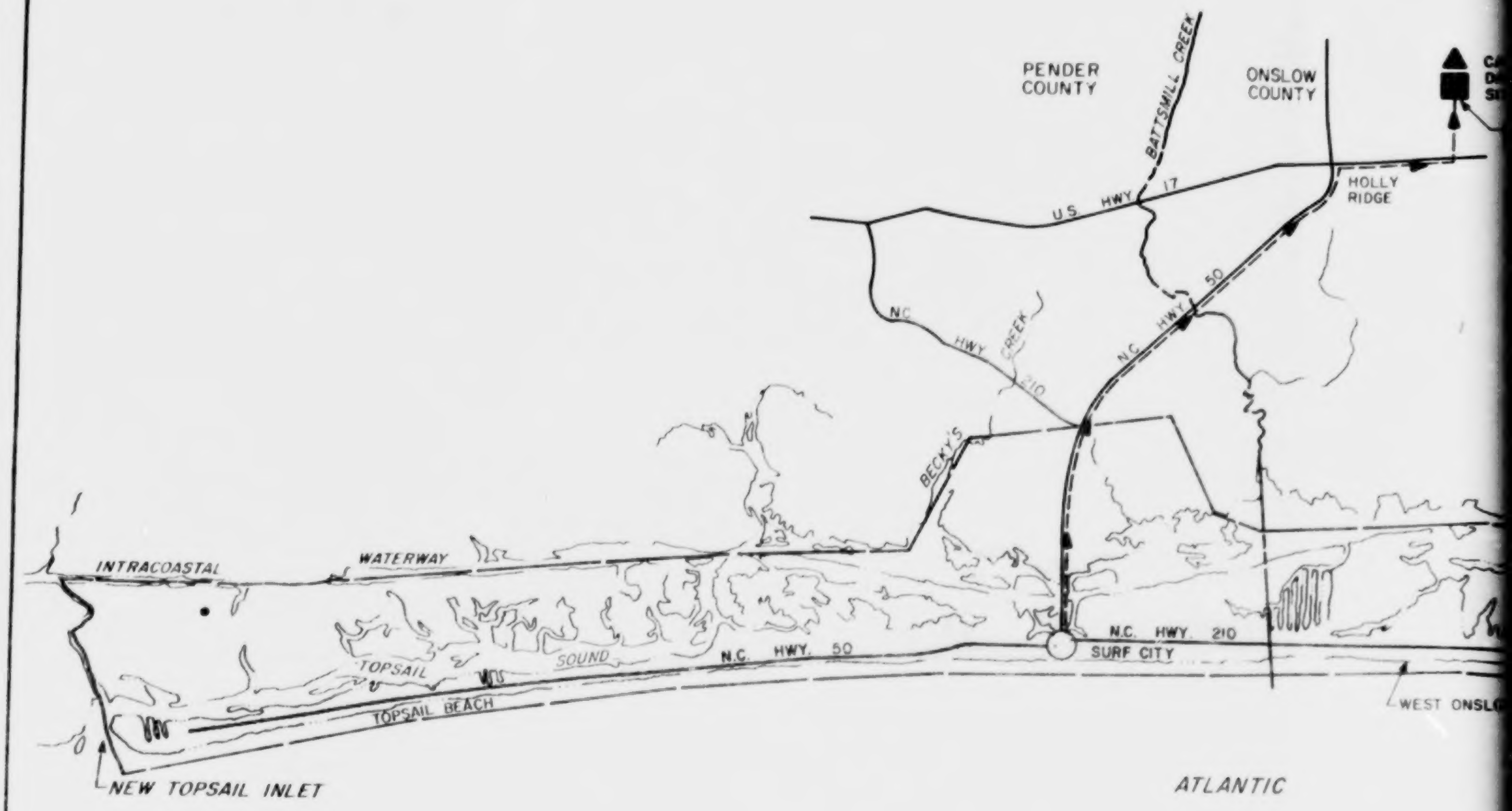
The collected wastewater flows would be treated by a newly constructed stabilization lagoon treatment system on a site at Camp Davis west of Holly Ridge which is outside the planning area's borders. These facilities are designed to handle a flow of 8,717 m^3/d (2.3 mgd), and all sludge would be collected and disposed at a sanitary landfill.

The treated effluent would then be disposed of by land application via a solid set spray irrigation system on a pine forest site near the treatment facilities. The 101 ha (250 ac) site is located in an isolated rural area and will be leased from the International Paper Company, Inc.

Costs developed in 1979 for implementing the proposed 201 Plan are presented in Table 2.1.3.

Financial Aspects

It is anticipated that EPA will provide 75 percent funding for grant-eligible design and construction costs. Land application and pressure sewers are eligible for 85 percent funding from EPA, provided funds are available. The combined total federal share amounts to $11,357,520. The State will provide $729,024 for design and construction of the interceptor and treatment


PENDER COUNTY
BATTSMILL CREEK
ONSLOW COUNTY
U.S. HWY 17
HOLLY RIDGE
N.C. HWY 50
N.C. HWY 210
CREEK
BECKY'S
INTRACOASTAL
WATERWAY
TOPSAIL
SOUND
N.C. HWY. 50
TOPSAIL BEACH
N.C. HWY. 210
SURF CITY
WEST ONSL
NEW TOPSAIL INLET
ATLANTIC

LEGEND

—— 201 FACILITIES PLANNING AREA
– – – MAJOR FORCE MAIN
■ WASTEWATER TREATMENT FACILITY
○ PUMPING STATION
▲ LAND APPLICATION
▭ SEWAGE SERVICE DISTRICT

BARRIER ISLANDS E.I.S.

U.S. ENVIRONMENTAL PROTECTION AGENCY
REGION IV

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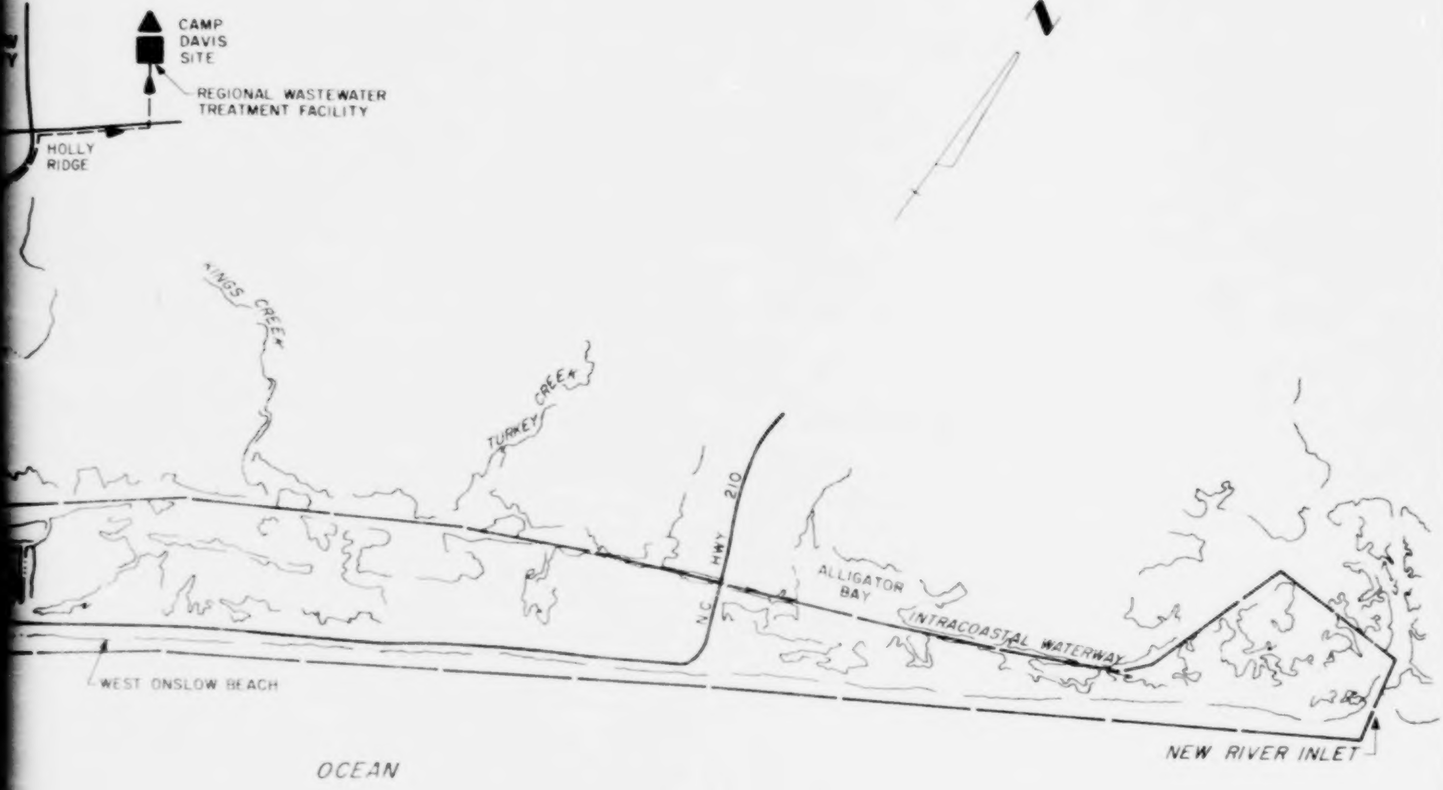

CAMP
DAVIS
SITE
REGIONAL WASTEWATER
TREATMENT FACILITY
HOLLY
RIDGE
KINGS CREEK
TURKEY CREEK
N.C. HWY 210
ALLIGATOR
BAY
INTRACOASTAL WATERWAY
210
WEST ONSLOW BEACH
OCEAN
NEW RIVER INLET

Figure 2.1.3

REGIONAL ALTERNATIVE PLAN
SINGLE FACILITY LOCATED AT CAMP DAVIS SITE
WITH LAND APPLICATION OF EFFLUENT

S.

Prepared by:
CLAUDE TERRY & ASSOCIATES, INC. ATLANTA, GA.
GANNETT FLEMING CORDDRY AND CARPENTER, INC.

201 FACILITIES PLANNING AREA
TOPSAIL-SURF CITY

6,000 0 6,000 12,000
SCALE IN FEET

systems. Local jurisdictions will be responsible for the remaining $1,975,108 in design and construction funds and will need to generate annual revenue of $375,750 for operations and maintenance.

It is anticipated that the local share of the project costs will be supported by general obligation bonds. The general obligation bonds and O&M costs will be repaid from revenues derived from a system of sewer user charges. Final project costs based on actual bids will determine the amount of bonds to be issued. The actual number of users at the time of project completion will determine the actual user charges. These charges will be prorated based on peak seasonal populations in each local jurisdiction. The estimated average monthly sewer user charge ranges from $11.49 to $14.28.

Table 2.1.3 Estimated Project Capital Costs and Annual Local Costs for Topsail/Surf City.

	Total Cost	Federal Cost	State Cost	Topsail	Surf City	West Onslow	Pender County
Design	$724,494	$592,905	$28,645	$27,383	$30,986	$38,501	$6,074
Construction	11,777,009	9,634,200	629,119	403,642	455,621	566,120	89,307
Other	1,560,148	1,130,415	71,260	95,354	107,901	134,069	21,150
Total	$14,061,651	$11,357,520	$729,024	$525,370	$594,508	$738,690	$116,531
Local Annual Debt Service				$31,145	$35,242	$43,790	$6,908
Local Annual O & M				68,805	77,858	96,741	15,261
Total Local Annual Cost				$99,950	$113,100	$140,531	$22,169

Source: Henry Von Oesen and Associates. 1980. Topsail-Surf City 201 Facilities Plan.

Institutional Aspects

The participating local units of government have agreed that some form of regional management agency is the best method for operating the proposed wastewater treatment system. The agency structure has not been delineated, but various alternatives are under consideration. The 201 Plan identifies the formation of this agency and the enactment of a lease agreement with the International Paper Company for use of the land application site as the two most important steps in the implementation process.

A schedule of implementation steps is included in the plan as well as a listing of permits that are required for project implementation. In addition, the required operation and maintenance personnel specifications and operation manual are referenced.

TREATMENT FACILITY, MANAGED BY METROPOLITAN WATER DISTRICT, TO BE SUPPORTED BY LOCAL USER CHARGES, FEDERAL AND STATE DOLLARS

The selected facility plan involves three separate treatment and disposal systems, one of which is located on Bogue Banks. This 3,866 m^3/d (1.02 mgd) secondary treatment facility will use an ocean outfall to dispose of treated effluent. Projected local costs (excluding the ocean outfall) are to be collected from user charges levied by a proposed Metropolitan Water District.

Technical Aspects

On the mainland, Beaufort and Moorhead City will each be served by a central wastewater treatment system. A third facility will be located at Pine Knoll Shores on Bogue Banks. The location of these systems is shown on Figure 2.1.4.

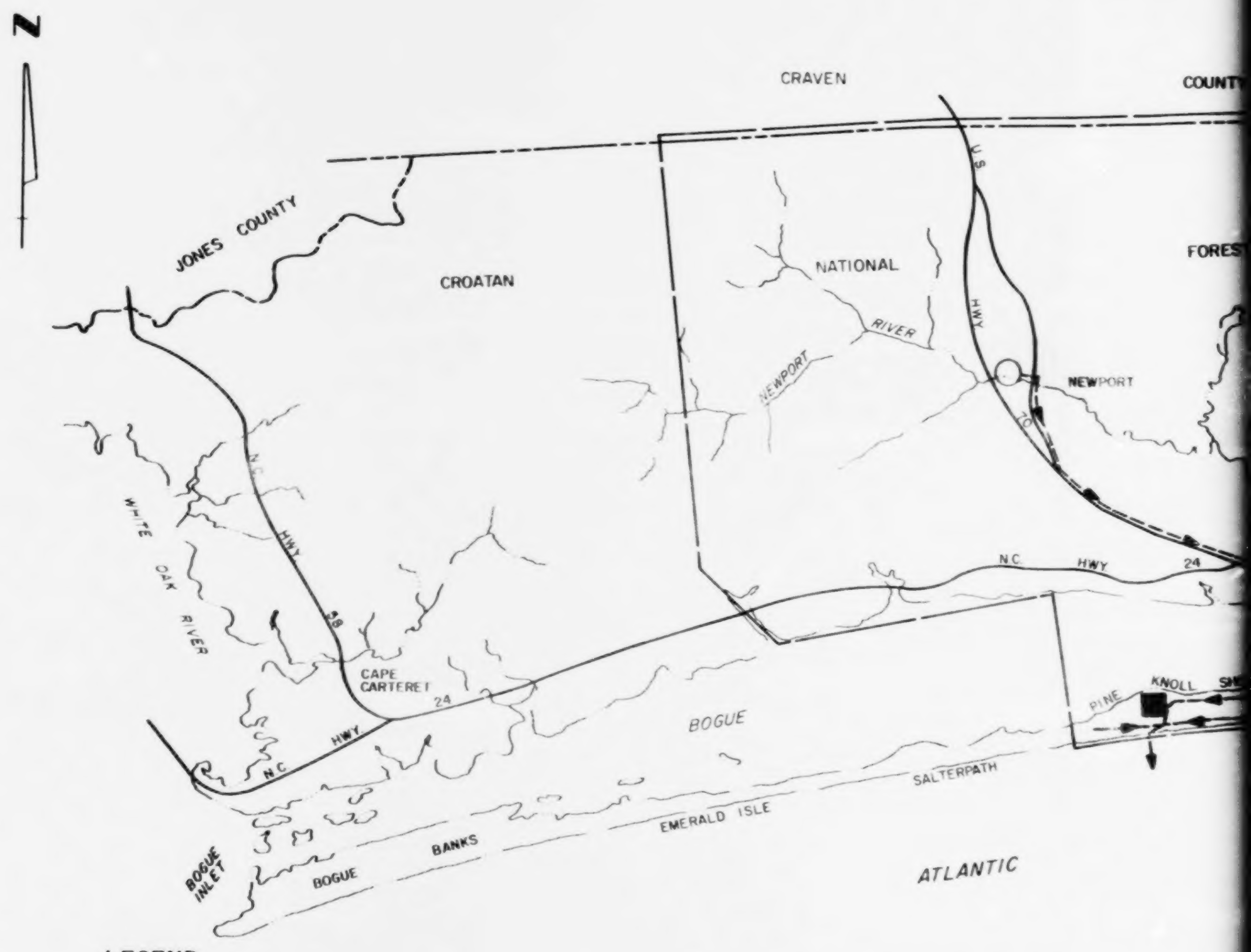
The service areas that would utilize the proposed treatment facilities at Pine Knoll Shores are part of East Bogue Banks and include the communities of Atlantic Beach and Pine Knoll Shores plus all the newly annexed areas adjacent to Atlantic Beach. The Atlantic Beach collection system would be a conventional gravity sewer system consisting of gravity sewer mains, manholes, laterals, service clean-outs, lift stations and force mains. All flows would then be directed to a central lift station which would pump the collected wastewater via a force main to the 3,866 m^3/d (1.02 mgd) regional wastewater treatment works at Pine Knoll Shores. The Pine Knoll Shores collection system is proposed to be a pressure sewer system based on a grinder pump alternative.

Effluent disposal would be via an ocean outfall that is proposed to extend 1.61 km (1.0 mi) offshore into the Atlantic Ocean. The 201 Facilities Plan calls for the completion of a marine site survey in order to define the exact location, length, etc. of the outfall and to provide specific design data on the pipeline and its diffuser section.

Project costs as presented in the draft 201 Plan are presented in Table 2.1.4 for Atlantic Beach and Pine Knoll Shores.

Financial Aspects

Grants from EPA are expected to finance 75 percent of the eligible construction costs of the treatment facility and interceptor projects associated with this plan. One project, the pressure sewer system for Pine Knoll Shores, can anticipate an 85 percent grant under the alternative technology provisions of the Clean Water Act. This support is contingent on the continuance of the current level of funding by the federal government.


N
CRAVEN
COUNTY
JONES COUNTY
CROATAN
NATIONAL
FOREST
NEWPORT RIVER
U.S. HWY 70
NEWPORT
WHITE OAK RIVER
N.C. HWY 58
CAPE CARTERET
N.C. HWY 24
BOGUE
PINE KNOLL SH
SALTERPATH
EMERALD ISLE
BOGUE BANKS
BOGUE INLET
ATLANTIC

LEGEND

——	201 FACILITIES PLANNING AREA BOUNDARY
– – –	MAJOR FORCE MAIN
■	WASTEWATER TREATMENT FACILITY
○	PUMPING STATION
▭	SEWAGE SERVICE DISTRICT

BARRIER ISLANDS E.I.S.

U.S. ENVIRONMENTAL PROTECTION AGENCY
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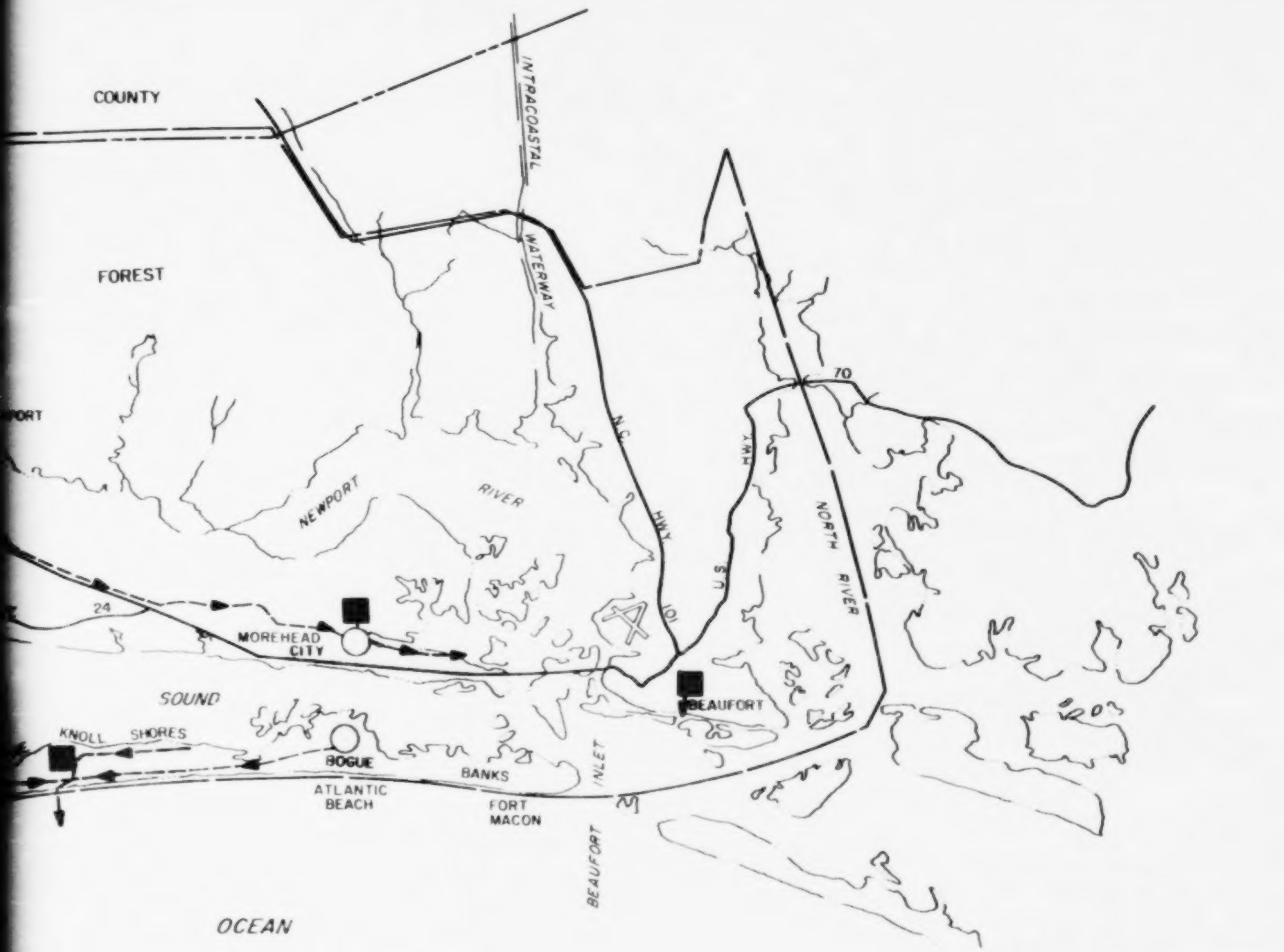
COUNTY
FOREST
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WATERWAY
PORT
NEWPORT
RIVER
N.C.
HWY
101
U.S.
HWY
70
NORTH
RIVER
24
MOREHEAD
CITY
5
SOUND
KNOLL
SHORES
BOGUE
BANKS
ATLANTIC
BEACH
FORT
MACON
INLET
BEAUFORT
BEAUFORT
OCEAN

Figure 2.1.4

REGIONAL ALTERNATIVE PLAN
3 SEPARATE TREATMENT FACILITIES WITH
EFFLUENT DISCHARGE TO ATLANTIC OCEAN,
TAYLORS CREEK, AND NEWPORT RIVER

S.

Prepared by:
CLAUDE TERRY & ASSOCIATES, INC. ATLANTA, GA.
GANNETT FLEMING CORDDRY AND CARPENTER, INC.

201 FACILITIES PLANNING AREA
CARTERET COUNTY COMPLEX

1 0 1 2 3 4
SCALE IN MILES

2.1.4 Continued

Furthermore, it is anticipated that the non-federal portion of the EPA-eligible costs will be financed by state grants amounting to 12.5 percent (7.5 percent in case of an 85 percent federal grant) of the eligible construction costs, provided the existing level of state participation is maintained by continuation of Clean Water Bond Act funds. The anticipated local share for all projects is therefore estimated at 12.5 percent of the grant eligible portion plus 100 percent of the non-grant eligible amount.

Local funds for the project are to be collected solely through a user charge system. Although the plan mentions that other revenue sources may be used, the projected costs do not warrant issuing general obligation bonds. Local monthly user charges are estimated at $8.31 for Atlantic Beach and $11.09 for Pine Knoll Shores. These figures include the cost of constructing an ocean outfall based on a cost of $61/linear meter ($200/linear foot) of pipe.

Table 2.1.4 Estimated Project Capital Costs and Annual Local Costs for Carteret County/Bogue Banks.

	Atlantic Beach	Local Share	Pine Knoll Shores	Local Share
Ocean Outfall Study	$37,500	$ 5,016	$ 37,500	$ 5,016
Treatment Facility	1,420,205	189,953	1,420,205	189,953
Pumping Station/ Force main	824,057	110,217	175,910	23,527
Collection System	2,480,590	331,778	1,644,687	131,986
Total	$4,762,352	$636,964	$3,278,302	$350,482
Local Annual Debt Service		$41,465		$17,081
Local Annual O&M		97,409		78,079
Total Local Annual Cost		$138,874		$95,160

Source: William F. Freeman Associates and Henry Von Oesen and Associates. 1979. Carteret County Complex 201 Facilities Plan.

Institutional Aspects

The 201 Plan investigates seven possible institutional arrangements which could serve the needs of Bogue Banks. The recommended organization is a Metropolitan Water District, chosen because future growth may make it advantageous for the MWD to control both sewer and water systems. The plan also recognizes that the governmental units must negotiate implementation agreements which would require significant time and energy from all parties to determine equitable agreements.

A description of the general implementation steps and a schedule of events are presented to clarify future responsibilities for completing the treatment facility. In addition, staffing requirements, organizational

2.1.4 Continued

structure and operations and maintenance needs are detailed for each facility component.

Pine Knoll Shores has not agreed to participate in the draft 201 Plan as described. This will necessitate a modification of the original plan either to include Pine Knoll Shores in an alternative which it approves or prepare another plan which does not include it.

PROPOSED REGIONAL SYSTEMS TOO EXPENSIVE

Two service areas were delineated on Hatteras Island. Each would be served by conventional gravity flow sewers and pump stations. After secondary treatment, effluent would be disposed by rotary distributors. Sludge would be transported to the county landfill. User cost estimates ranged from $336.00 to $402.48 per year.

Technical Aspects

The Hatteras Island planning area is located in the southern portion of Dare County. The wastewater planning area was subdivided into two service districts. The first coincides with the public water supply district boundaries, the Cape Hatteras Water Association (CHWA) service area, comprising the villages of Avon, Buxton, Frisco and Hatteras. The second service area contains the villages of Rodanthe, Waves and Salvo. The location of these systems is shown in Figure 2.1.5.

Three similar structural alternatives were considered for the CHWA area and two for the Rodanthe/Waves/Salvo (RWS) area. Wastewater would be collected and transported by conventional gravity flow sewers and pump stations. Treatment included grit removal, equalization, activated sludge treatment, filtration and disinfection. Sludge would be aerobically digested and dewatered mechanically in the CHWA area and dewatered on drying beds in the RWS area. Dried sludge would then be transported to the county landfill on Roanoke Island. Effluent would be disposed by rotary distributors.

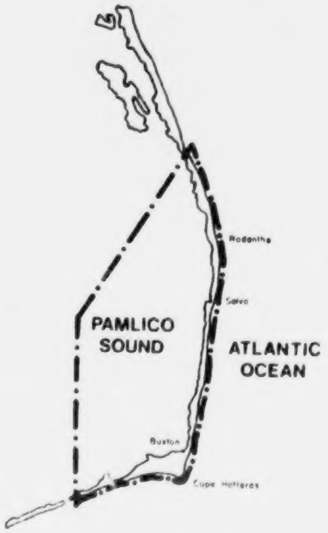
Financial Aspects

The least costly alternative for the CHWA area involved a regional system with treatment and disposal at Avon in Buxton Woods. The least costly alternative for the RWS area was a regional system with treatment and disposal at a site between Rodanthe and Waves. Project costs as presented in the draft 201 Plan are shown in Table 2.1.5.

The 201 consultants have recommended that no action be taken on the proposed structural alternatives because user charges are too high to be affordable. Even with additional collector system grants from FmHA, annual user charges for a typical household would approach $402.48 for the CHWA area and $336.00 for the RWS area.

Institutional Aspects

System management was not addressed since the 201 consultants recommended no action.


Rodanthe
Salvo
PAMLICO SOUND
ATLANTIC OCEAN
Buxton
Cape Hatteras

LOCATION MAP

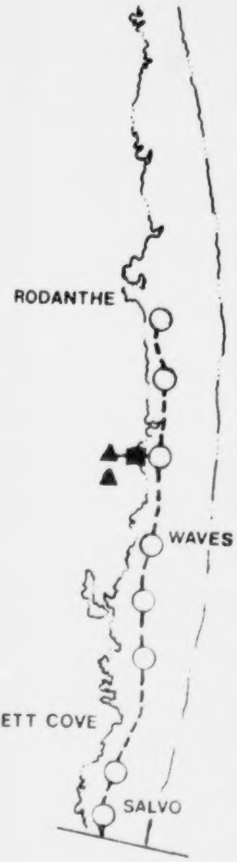

RODANTHE
WAVES
MIDGETT COVE
SALVO

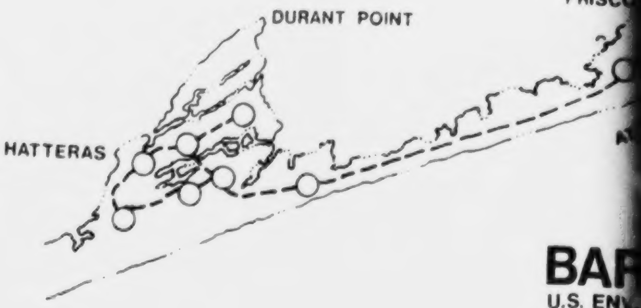
Figure 2.1.5

201 FACILITIES PLANNING AREA
HATTERAS ISLAND

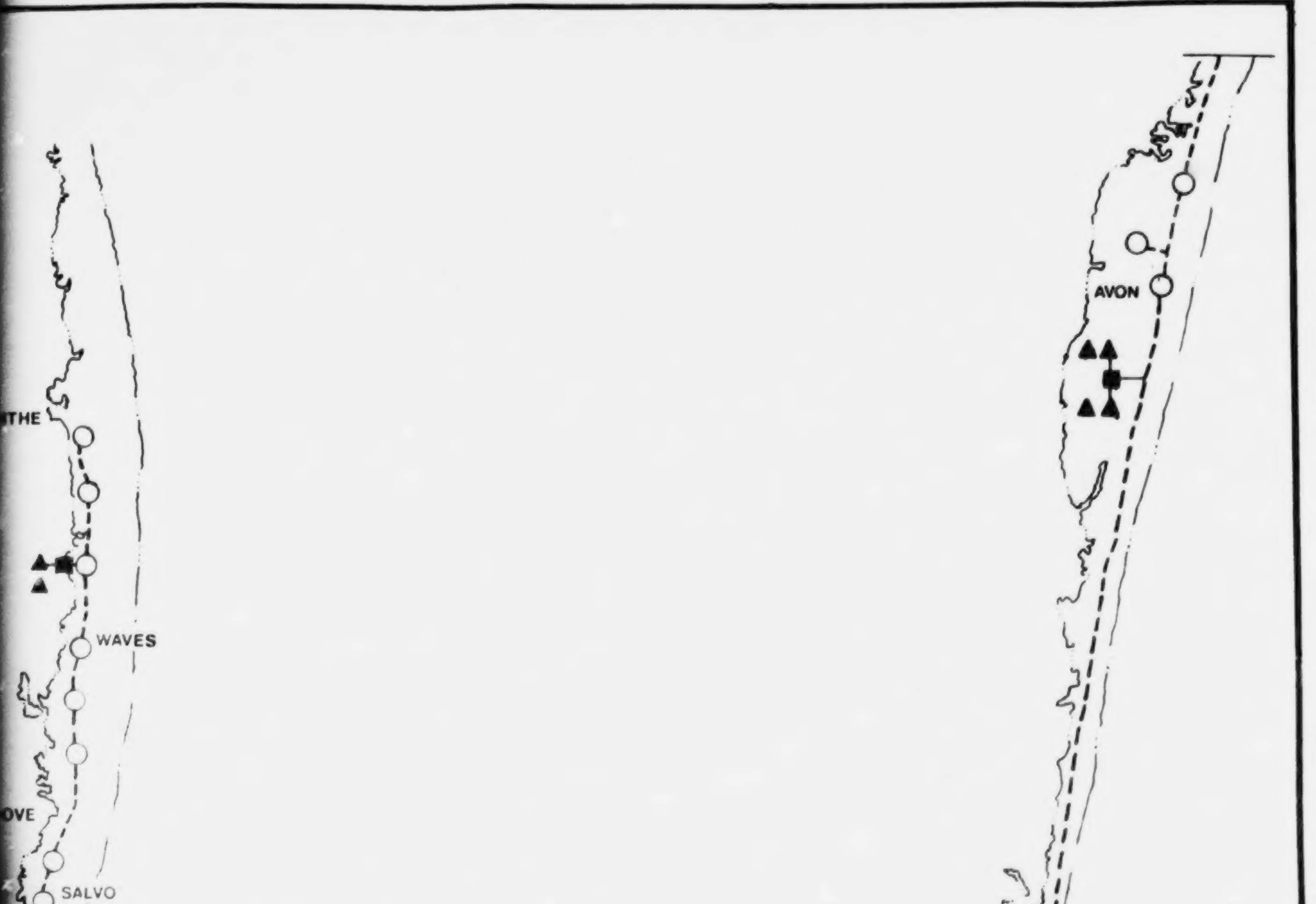
NOTE: Not All Pumping Stations Are Shown

LEGEND

- ---- MAJOR FORCE MAIN
- ■ WASTEWATER TREATMENT FACILITY
- ○ PUMPING STATION
- ▲ LAND APPLICATION


DURANT POINT
FRISC
HATTERAS

BAR
U.S. ENV
REGION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OVE
SALVO
AVON
BUXTON
FRISCO
NT
CAPE HATTERAS
ATLANTIC OCEAN
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SCALE IN FEET

BARRIER ISLANDS E.I.S.

U.S. ENVIRONMENTAL PROTECTION AGENCY
REGION IV

Prepared by:
CLAUDE TERRY & ASSOCIATES, INC. ATLANTA, GA.
GANNETT FLEMING CORDDRY AND CARPENTER, INC.

Table 2.1.5. Estimated Project Capital Costs and Annual Local Costs for Hatteras Island.

	Avon/Buxton/ Frisco/Hatteras	Rodanthe/ Waves/Salvo
Interceptors & Collectors		
Capital Cost (Initial)	$21,478,000	$5,060,000
Avg. Annual O&M	134,000	29,000
Present Worth	19,579,000	4,584,000
Treatment Facility		
Capital Cost (Initial)	6,957,000	2,572,000
Avg. Annual O&M	208,000	117,000
Present Worth	8,373,000	3,731,000
Total Present Worth	27,544,000	8,315,000
Total Capital Costs	28,285,000	7,632,000
EPA Share	11,347,500	3,375,000
State Share	1,891,250	562,500
Local Share	15,046,250	3,694,500
Annual Local Cost	1,244,000	276,000
Typical Household Annual User Charge	685	600

Source: Moore, Gardner & Associates, Inc. October 1981. Hatteras Island 201 Wastewater Facilities Plan.

REGIONAL TREATMENT FACILITY OPERATIONS FINANCED BY BONDS AND USER CHARGES UNDER JOINT COUNTY AND MUNICIPAL GUIDANCE

The selected plan proposes a collection and treatment system to service most of Roanoke Island and the barrier island beaches. The 13,644 m^3/d (3.6 mgd) regional treatment facility would be located at Nags Head and would provide secondary treatment. Treated effluent would be disposed via an ocean outfall. Costs, excluding collection system costs, would be paid by user fees and general obligation bonds. Each governmental unit would be party to an interlocal contract stipulating management and financial responsibilities.

Technical Aspects

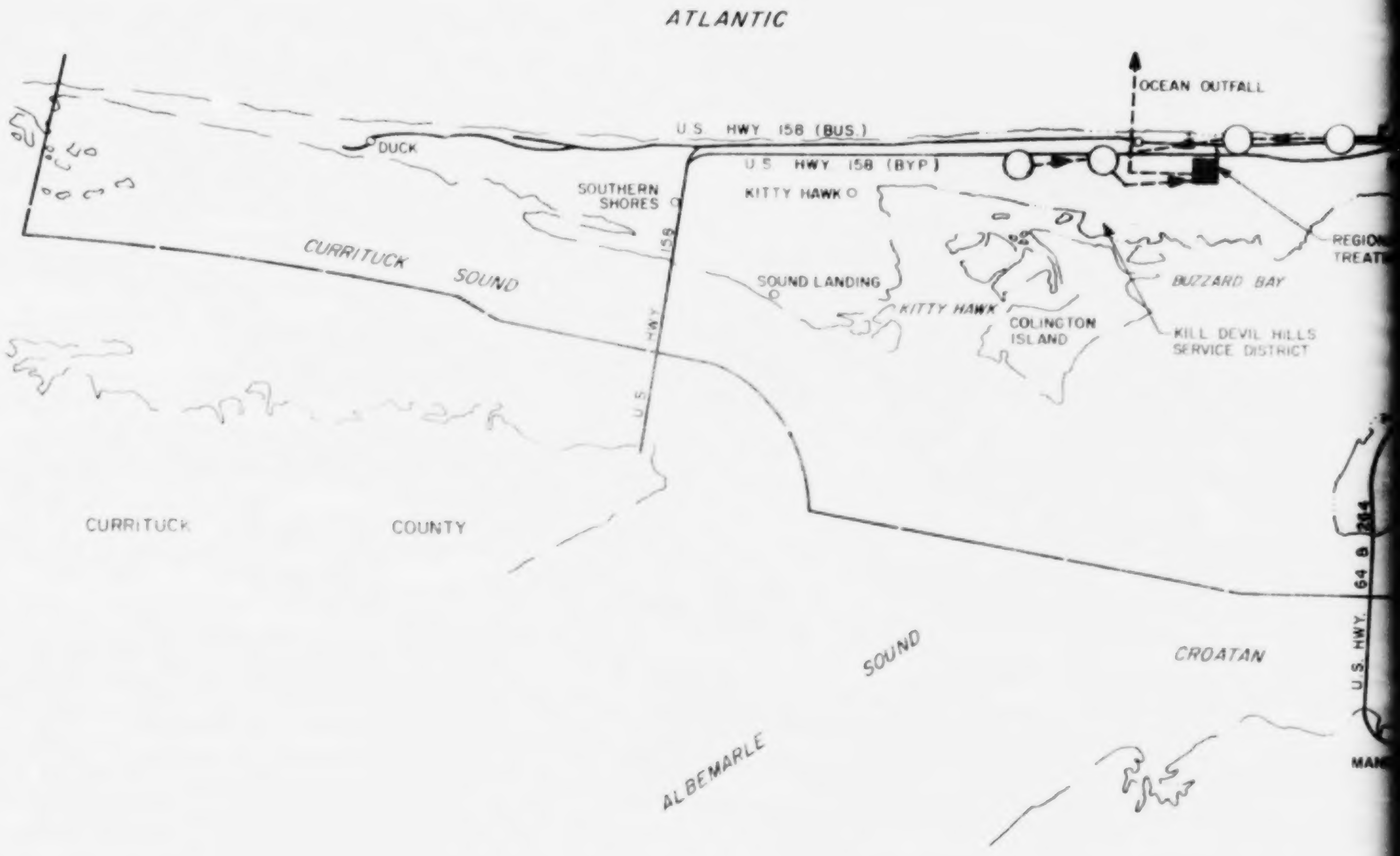
The collection and interceptor system would include major wastewater pumping stations with the main interceptor running along Bodie Island. The areas to be served are those with existing critical needs and/or those areas having a high priority to receive the full range of public services, according to the Dare County Coastal Area Management Act Land Use Plan. Service areas include Kill Devil Hills, Nags Head, Whalebone-South Bodie Island, Manteo and Wanchese. A subaqueous force main, joining the main interceptor in the vicinity of Whalebone Junction, would transport the wastewater from the Roanoke Island service areas (Manteo and Wanchese). The regional treatment facilities will be located at Nags Head on land owned by the town near the existing water treatment plant. The locations of these facilities are shown in Figure 2.1.6.

The subaqueous outfall would include a multi-port diffuser system located 1.61 km (1.0 mi) offshore in the Atlantic Ocean. The 201 Facilities Plan proposal calls for a marine site survey consistent with EPA interim regulations on ocean outfalls to be conducted in order to gather more information for proper design. This study is being conducted at the present time.

Sludge handling would be by aerobic digestion and dewatering on sand drying beds. Final disposal would be at the Dare County Sanitary Landfill at Manteo by contracted hauling. Costs associated with the projected regional facility (treatment plant and interceptor lines) are presented in Table 2.1.5. These figures do not include the cost of collector sewers and service laterals.

Financial Aspects

A series of grants from the EPA are expected to finance 75 percent of the eligible design and construction costs of the projects associated with this facility plan. It is anticipated that the non-federal portion of the marine site survey for the ocean outfall will be financed in part by a state grant amounting to 12.5 percent of the eligible costs. The local costs shown


ATLANTIC
OCEAN OUTFALL
U.S. HWY 158 (BUS.)
U.S. HWY 158 (BYP.)
DUCK
SOUTHERN SHORES
KITTY HAWK
REGION
TREAT
CURRITUCK SOUND
U.S. HWY 158
SOUND LANDING
KITTY HAWK
COLINGTON ISLAND
BUZZARD BAY
KILL DEVIL HILLS SERVICE DISTRICT
CURRITUCK COUNTY
U.S. HWY. 64 & 264
SOUND
CROATAN
ALBEMARLE
MAN

LEGEND

——	201 FACILITIES PLANNING AREA BOUNDARY
- - - -	MAJOR FORCE MAIN
■	WASTEWATER TREATMENT FACILITY
○	PUMPING STATION
▭	SEWAGE SERVICE DISTRICT

BARRIER ISLANDS E.I.S.
U.S. ENVIRONMENTAL PROTECTION AGENCY
REGION IV

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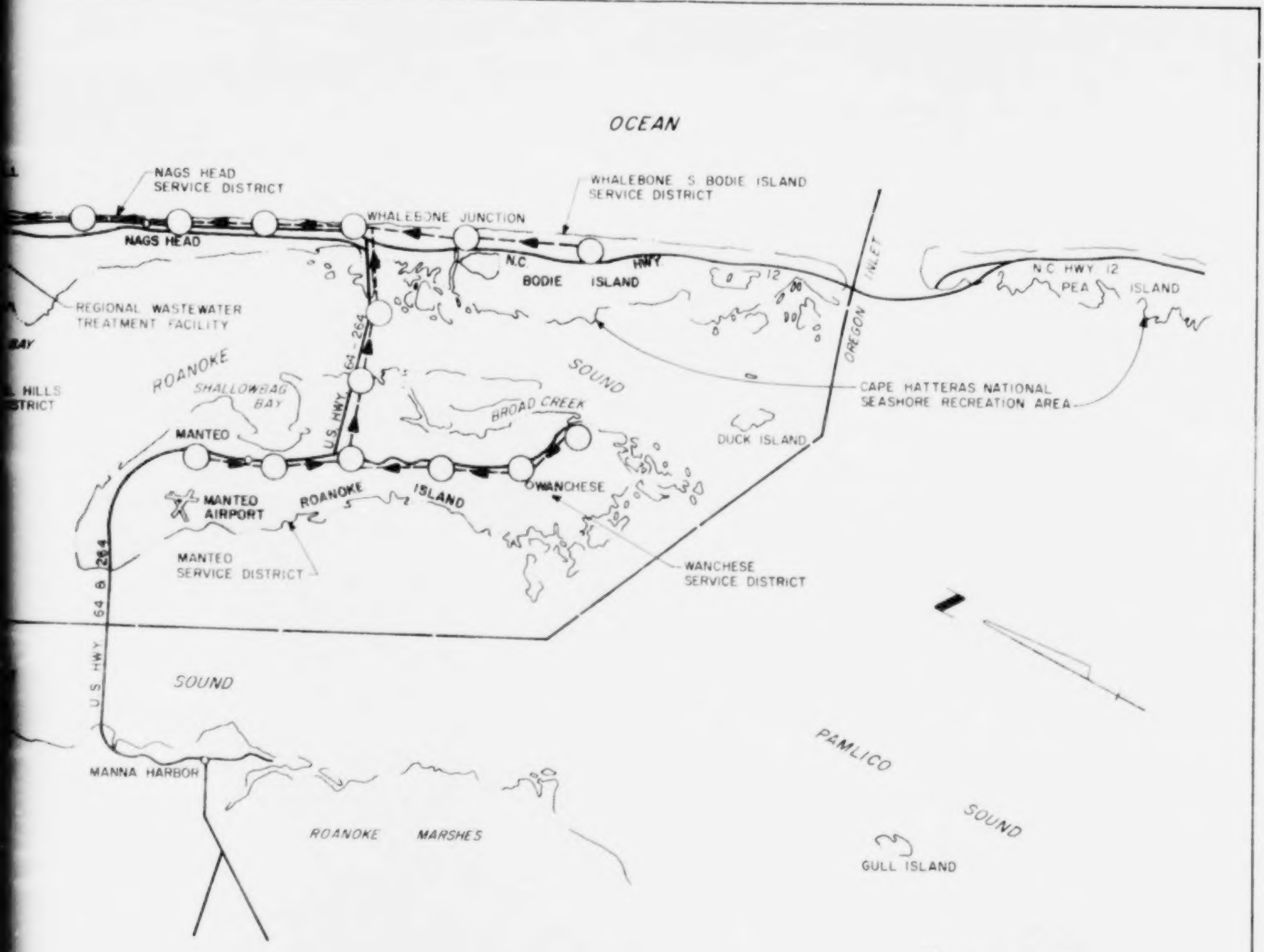

OCEAN
NAGS HEAD SERVICE DISTRICT
NAGS HEAD
WHALEBONE JUNCTION
WHALEBONE & BODIE ISLAND SERVICE DISTRICT
N.C. HWY
BODIE ISLAND
12
OREGON INLET
N.C. HWY 12
PEA ISLAND
REGIONAL WASTEWATER TREATMENT FACILITY
BAY
HILLS
STRICT
ROANOKE
SHALLOWBAG BAY
SOUND
U.S. HWY 64-264
BROAD CREEK
CAPE HATTERAS NATIONAL SEASHORE RECREATION AREA
DUCK ISLAND
MANTEO
MANTEO AIRPORT
ROANOKE ISLAND
WANCHESE
MANTEO SERVICE DISTRICT
WANCHESE SERVICE DISTRICT
U.S. HWY 64 & 264
SOUND
MANNA HARBOR
ROANOKE MARSHES
PAMLICO SOUND
GULL ISLAND
0 1 2 3 4
SCALE IN MILES

Figure 2.1.6

REGIONAL ALTERNATIVE PLAN
SINGLE FACILITY AT NAGS HEAD WITH EFFLUENT DISCHARGE TO ATLANTIC OCEAN

201 FACILITIES PLANNING AREA
DARE COUNTY COMPLEX

Prepared by:
CLAUDE TERRY & ASSOCIATES, INC. ATLANTA, GA.
GANNETT FLEMING CORDDRY AND CARPENTER, INC.

2.1.6 Continued

in Table 2.1.5 represent all non-federal costs. Under current cost sharing regulations, the state would pay 12.5 percent of grant eligible costs, approximately $1,244,000. The local governments would then be responsible for about $1,870,150. The local share includes 12.5 percent of grant eligible costs and all non-grant eligible costs.

The local share of the project capital costs will have to be met by the issuance of general obligation bonds. The operation and maintenance costs of the treatment works (plants and interceptors) will be paid by a system of user charges. Two user charge systems are proposed: 1) charge each user a set rate based on proportional wasteload contribution, or 2) determine classes of use (domestic, commercial, industrial) and develop charges based on wastewater characteristics and flow. The 201 Plan recommends the latter method.

Table 2.1.6 Estimated Project Capital Costs and Annual Local Costs for Dare Beaches Complex

	Total	State	Local	Federal
Ocean Outfall Study	$120,000	$15,000	$15,000	$90,000
Interim Sludge Handling - Manteo	107,517		32,517	75,000
Treatment Plant and Outfall	4,212,228		1,240,557	2,971,671
Regional Interceptor	6,171,815		1,826,079	4,345,736
Total	10,611,560	$15,000	$3,114,153	$7,482,407
Local Annual O & M	$239,589			
Local Annual Debt Service	183,178			
Total Local Annual Cost	$423,307			

*Includes state share of grant eligible costs - approximately $1,244,000 or 12.5 percent.

Source: Henry Von Oesen and Associates. 1977. Dare County Complex 201 Facilities Plan.

Institutional Aspects

The 201 Plan for Dare Beaches Complex recommended the most complex intergovernmental cooperation alternative of the six pending plans. The county would be involved with several municipalities in establishing and operating the proposed wastewater treatment collection and treatment facilities. Therefore, the 201 Plan has identified and assessed seven different institutional management options, selecting an Interlocal Contract as the most workable and flexible mechanism for coordinating the interest of all jurisdictions. The administrative and operational and maintenance organization and procedures being established for the county's regional water supply system are well suited to expansion for this purpose.

2.1.6 Continued

The Plan recommends that the county be responsible for identifying the unincorporated areas where service is needed and that local collection systems be constructed to meet these requirements and installed on a carefully phased basis. The normal procedures for obtaining expressions of the desire for this service from the citizens of these selected areas would be followed. General obligation bond issues would have to be approved by public referendum, and financial arrangements for construction of the collection systems and the wastewater treatment facilities would have to be concluded. Again, it is proposed that the incorporated towns construct their own municipal sewage collection systems and the county construct the collection systems in the unincorporated areas to be serviced, with all citizens within the Community Service District supporting the local-share costs of the regional facilities (main interceptor and treatment facility) on an equitable basis through user charges.

Several problems are mentioned in the 201 Plan. The Interlocal agreements must be negotiated; each jurisdiction must take similar steps to assure that all system elements are completed; and each governmental unit must develop and implement sewage collection systems. In addition, the issue of a user fee schedule must be addressed by a joint committee from all jurisdictions to arrive at an equitable distribution of costs.

The 201 Plan proposes a time schedule for project implementation, directly addressing the general management, financial and design needs of the proposed collection and treatment facilities. Operation and maintenance requirements have been listed with an assessment of manpower and budgetary needs.

Provisions for industrial cost recovery have also been addressed in anticipation of the ultimate development of Wanchese Seafood Industrial Harbor. Annual cost recovery from industrial sources is projected at $21,000. However, industrial cost recovery requirements were repealed as of December 27, 1977. Construction grant regulation 35.928 ICR is no longer in force.

TECHNICAL COMPONENTS OF PROPOSED WASTEWATER SYSTEMS ARE DETAILED; INSTITUTIONAL AND FINANCIAL ASPECTS REQUIRE FURTHER EVALUATION

Centralized wastewater treatment facilities have been proposed for all barrier island study areas. While preliminary cost analyses indicate financial viability for five of the six areas, all system component costs have not been detailed. Furthermore, institutional agreements among participating units of government have not been finalized; thus some critical questions remain unanswered.

Technical Aspects

The 201 Facilities Plans proposed for North Carolina's barrier islands exhibit several similarities. Each plan calls for the replacement of existing on-site wastewater treatment systems with centralized collection, transmission, treatment and disposal facilities. Justification for this structural solution is found in reports of shellfish harvest area closings due to elevated fecal coliform counts and is based on the prediction that continued rapid residential and commercial development using on-site systems would lead to additional shellfish area closings. Localized studies have determined that existing on-site soil absorption systems have caused water quality problems. The reasons for on-site system failures have been attributed to high ground water tables, faulty installation, poor maintenance and unsuitable soils.

Another similarity is the proposal to provide sewer lines to all areas of the identified communities, regardless of the current level of development. Sewer availability will then be provided for all future development. In all cases, the individual collection systems are to be designed and constructed by each local jurisdiction.

Pumping stations and force mains are to be used in all facilities to transport effluent to the treatment plant. Secondary treatment would be provided at each plant prior to ocean disposal in Dare and Carteret counties, spray disposal in Topsail/Surf City, Hatteras Island and Southwest Brunswick County, and surface water discharge to the Cape Fear River in Southeast Brunswick County.

Financial Aspects

Each of the wastewater treatment systems (except Hatteras Island) proposed for the barrier islands is considered economically feasible by local officials as presented in the draft plan. However, the cost figures which have been developed cover only those portions of the treatment facilities (transmission, treatment and disposal) which are eligible for federal funding. Costs for individual collection systems have not been factored into the figures presented in the draft 201 Plans for Dare Beaches and Southwest Brunswick County.

2.2 Continued

All of the 201 Plans anticipate that at least 75 percent federal funding (85 percent for alternative and innovative system components) will be available for Step 2 and Step 3 activities. In addition, 12.5 percent state funds for conventional systems and 7.5 percent for innovative systems are expected to be available, leaving the remaining costs to be borne by the local participants. The details of this funding source, how it is accessed, and when and where it may be applied are not discussed in any of the 201 Plans. Figure 2.2 illustrates federal/state/local cost sharing.

The local share of funds in each plan is to be generated by issuing general obligation bonds for system construction. In each plan locally administered user charges, based on the estimated monthly volume of effluent, will provide sufficient revenue to cover the local share of the debt service and annual operation and maintenance costs. User charges were projected on a household basis that does not differentiate between permanent and seasonal residents and would reflect a minimum flat fee for all 12 months for all users.

The annual debt service for each facility is calculated for the estimated grant eligible systems components and is based on the interest rate prevailing at the time each plan was prepared. Subsequently, inflation has significantly increased design and construction costs as well as the rate of interest. These new financial constraints will need to be addressed prior to Step 2 preparation.

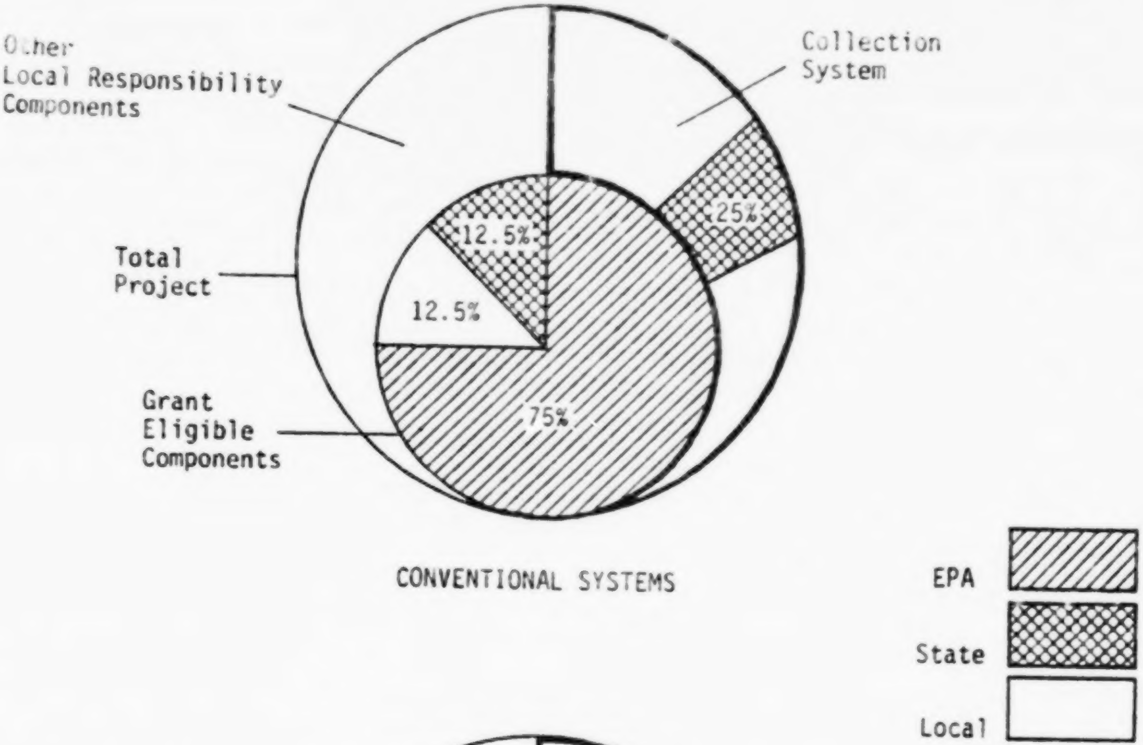
Costs for system components not covered by federal funding have been determined by several of the 201 Plans. These costs for collection systems and ocean outfalls have also increased and will have to be addressed by the individual local governments before proceeding further.

Institutional Aspects

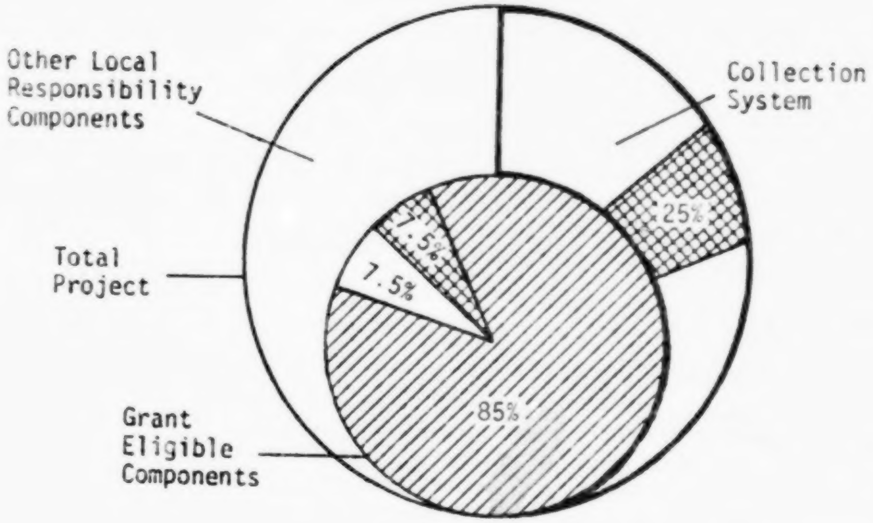
Institutional aspects of the 201 Facilities Plans are concerned with the type of agency necessary for managing and operating the wastewater treatment system, the responsibilities of the constituent governments, operations and maintenance needs and the development of a schedule for project design and construction. These elements must be addressed to assure that the proposed treatment system can be operated in a cost-effective manner.

The project schedule is the basic timetable for completing the design, developing management agreements, and obtaining the proper permits and meeting other legal requirements before construction may begin. Four of the proposed 201 plans provided schedules of necessary steps for project implementation, but the Southeastern Brunswick County plan did not address implementation procedures.

Operation and maintenance needs were discussed in each of the 201 Plans. The level of detail varied but general manpower requirements, equipment needs and annual O&M costs were presented in each plan. Maintenance manuals for each system would be prepared as part of the Step 2 detailed design phase.



CONVENTIONAL SYSTEMS



INNOVATIVE/ALTERNATIVE SYSTEMS

Figure 2.2. Federal, State and Local Matching Funds in North Carolina.

Source: Claude Terry & Associates, Inc. 1981.

2.2 Continued

The Dare Beaches Complex 201 Plan is the only plan to specifically identify individual responsibilities for each constituent government. This plan gives recommended construction, operation and maintenance tasks to each party and states what arrangements must be negotiated before construction can begin. The other plans note that arrangements are necessary, but they do not assign responsibilities.

Both Dare and Carteret County plans have evaluated and recommended agencies legally eligible to administer the operation of the proposed facilities. The Topsail/Surf City, Southwest Brunswick County and Southeastern Brunswick County plans did not recommend a particular agency structure, although the need for such an organization is recognized as a necessary element for proceeding to Step 2 design.

3.0 NO FEDERAL ACTION ALTERNATIVE

NO FEDERAL ACTION ENVISIONS THE FUTURE WITHOUT EPA INVOLVEMENT

A conclusion in the EIS that marginal or uncertain water quality benefits would be gained could lead to a decision by EPA not to participate in the further planning for or funding of wastewater management facilities in the study area.

The No Federal Action Strategy is a baseline for evaluating environmental impacts of the other two strategies. It projects future conditions on the North Carolina barrier islands in the absence of federal investment in wastewater facilities.

Analysis of the No Federal Action Strategy shows continued growth on the barrier islands if publicly-owned and funded sewage treatment facilities are not constructed. In concept, this alternative does not restrict state, local or private investment in wastewater management. However, without the support of federal funds, the amount and the nature of additional treatment capacity in the study area in the future would be significantly different than under any of the alternative strategies discussed later.

Growth would take place in response to previously committed investments and continuing pressures for new residential construction that would be accommodated in large part either by hook up to existing systems, individual on-site treatment systems or by privately-owned package plants. Thus, no federal action does not imply lack of growth. The major differences between the No Federal Action alternative and the other alternative strategies would be the density of development, the viability of some of the private real estate developments in the area and the total and individual costs of wastewater management. Impacts on the natural environment could also be expected to differ under the funding and no-federal-funding alternatives.

The following sections present a brief overview of existing wastewater treatment systems in each 201 study area. Then based upon the current technical, institutional and financial mechanisms, projections will be made about how the barrier island communities will develop if they must finance wastewater treatment facilities without federal assistance.

ON-SITE WASTEWATER TREATMENT SYSTEMS SERVICE THE VAST MAJORITY OF BARRIER ISLAND PROPERTIES

Most domestic wastewater generated on the barrier islands is treated by conventional soil absorption systems. A few municipal wastewater treatment plants as well as some private package plants discharge to surface waters. Other private package plants discharge to the water table aquifer. Industrial discharges are primarily related to seafood processing and do not significantly affect water quality.

Individual On-Lot Systems

Most of the domestic wastewaters generated on or near the barrier islands are treated using septic tank soil absorption systems. These include the larger systems (greater than 11,370 l (3,000 gal per day) permitted by the Division of Environmental Management (DEM) that serve commercial establishments as well as smaller systems permitted by the county health departments that serve small commercial establishments and residences. Estimates of the 1980 peak summer populations served by on-lot disposal systems indicate that these 128,078 persons generate a wastewater discharge of approximately 34,110-37,900 m^3/d (9.0-10.0 mgd).

Treatments Plants With Surface Discharge

The Villas and Ocean Sands package plants in Dare County and the Wrightsville Beach municipal plant discharge to SC waters that could be classified SA if not for the wastewater discharge. These discharges were in existence prior to the classification of the state's waters. When the waters were classified, limited areas around the existing discharges were classified SC instead of SA to reflect the existing use of the waters for treated waste assimilation. The US Coast Guard stations at Oregon Ination of the state's waters. When the waters were classified, limited areas around the existing discharges were classified SC instead of SA to reflect the existing use of the waters for treated waste assimilation. The US Coast Guard stations at Oregon Inlet and Hatteras Inlet do, however, discharge to SA waters.

DEM is responsible for monitoring the effluent of the Villas, Ocean Sands and Wrightsville Beach plants. Operation and maintenance costs are the responsibility of the plant owners.

With the exception of a few wastewater treatment facilities and one laundromat, all the industrial wastewater discharges are associated with some type of fish/seafood processing wastes. These facilities often discharge to SA waters, but no water quality violations have been associated with the existing industrial discharges. Therefore, these industrial discharges are generally not considered a major influence on water quality.

3.1 Continued

One of the most significant industrial developments is the large seafood processing center and shipyard at Wanchese. When operations begin, this will be the largest concentration of industrial activity in the immediate vicinity of barrier islands. A 1,429 m^3/d (0.377 mgd) advanced secondary treatment plant has been constructed to handle wastewaters from these seafood processors.

Treatment Plants With Sub-Surface Disposal

Community sub-surface disposal systems are found on barrier islands in each 201 planning area with the exception of Southwest Brunswick County and Topsail/Surf City. Southeastern Brunswick County has three systems; Carteret supports systems on Bogue Banks; and Dare Beaches has eight sub-surface disposal facilities. These systems are regulated by DEM which mandates specific operations and maintenance procedures. The costs associated with all aspects of plant construction, operation and maintenance are the responsibility of the property owners.

Because the discharge of treated domestic wastewaters to SA waters has been prohibited by state regulation, newer package plants discharge to the water table aquifer, either by subsurface nitrification fields or distribution on the surface sands. These systems generally provide advanced treatment of wastewaters consisting of secondary biological treatment followed by positive solids removal prior to disposal.

Nitrification fields are used extensively in barrier islands communities. The package plant serving the Holiday Inn at Nags Head is an example of the rotary distribution system alternative. Both types of systems are generally referred to as non-discharge systems because they do not discharge to surface waters.

FUTURE DEVELOPMENT PATTERNS ARE AN EXTENSION OF EXISTING PATTERNS

The lack of further federal assistance for wastewater treatment facilities will not reduce growth pressures on barrier islands. Ultimately population densities could decrease as reliance on soil absorption systems requires larger lot sizes. Increasing land and development costs will lead to more multi-family construction to keep costs low, especially in Dare and Carteret beach areas. The remaining 201 areas would continue to develop single family homes on individual lots to retain "family beach" development.

Because of the similar natural environments and the tourist-oriented economies in the study area, development trends over the next 20 years will be generally similar for each 201 study location. Differences, such as the size of a community or proximity to a major city, may affect some aspects of barrier island life, but they do not alter the basic development trends.

Barrier island growth patterns will continue in the same direction that has occured for the past 15 years. Single family homes will predominate; multi-family structures will capture an expanding percentage of the total units built; commercial accomodations will retain the same percentage of units (except in Dare and Carteret) and auxilliary commercial establishments will be built to provide services for the new population.

Patterns of development on barrier islands are largely dictated by the elongated shape of the islands and the desire of island residents and visitors to be close to the water, preferrably the ocean. These two factors have resulted in linear development along island margins. This pattern was recognized and reinforced in the 201 Plans as sewers were designed to service existing development. Future development will continue in this mode because this pattern maximizes the amenities of shorefront living desired by island residents.

Available land parcels close to the ocean and the sounds will be the first to be developed regardless of the type of wastewater treatment facility required. However, if all other factors are equal, shorefront lots with good on-site system characteristics will be more desirable than those with poor on-site characteristics.

While the pattern of development would remain essentially the same as that in the proposed 201 Plans, the density of development would probably be less than if sewers were available. These lower densities would be necessary to accomodate the land area requirements mandated by the rules and regulations governing on-site soil absorption systems. Lots platted prior to July 1, 1977 may use on-site systems on parcels as small as 5000 square feet, which produces a density equivalent to approximately 8.7 units/acre. After that date, lots were required to be a minimum of 7500 square feet, which would accomodate approximately 5.8 units/acre. The above cases assume, however, that horizontal distance requirements can be met and that there is adequate area classified as suitable for subsurface treatment and disposal systems.

Densities will decrease significantly for lands platted after July 1, 1982, when the Department of Human Resources' new regulations governing soil absorption systems became effective. These regulations require even larger lots due to the need for a repair/replacement area of equal size and a 50 percent increase in absorption area requirements if beds instead of trenches are utilized. The new regulations will also make it more difficult for property owners to obtain an exception to the minimum horizontal distance requirements for previously platted lands; these lands must now consider using some type of community or public sewerage system. This will have the effect of reducing the total number of individual on-site systems for older and smaller lots.

Population growth rates on the islands have been dramatic. Many communities were virtually non-existent 25 years ago. The rate of new people setting or visiting the islands will continue at the same pace experienced over the past few years. The existing relationship between numbers of permanent and seasonal/overnight/day visitors is expected to remain approximately the same as presently found in each study area. Two areas, the seashore in Dare County and Atlantic Beach in Carteret County, are expected to have a greater increase in overnight visitorship than the other communities in 201 study area. These two locations cater more to transient tourists than the seasonal family vacationers found at locations such as Sunset Beach. Seasonal visitors are a major element in Dare County and Atlantic Beach, but the number of overnight visitors represents a greater proportion of the summer population thus indicating a greater need for overnight accomodations such as hotels, motels, campgrounds and hostels.

The following sections of this report discuss the technical, institutional and financial impacts produced by the No Federal Action Alternative.

SOIL ABSORPTION SYSTEMS WILL BE THE PREDOMINANT CHOICE

Individual or community on-site systems appear to be the most probable technical alternative in the study area. State regulations prohibit surface discharge to SA waters, and costs for mainland disposal and ocean outfalls are very high.

Wastewater treatment systems currently in operation on the barrier islands consist of on-site soil absorption systems, community soil absorption systems and a few large surface discharge systems. In the event additional federal funds are not available, future development will rely largely on soil absorption systems, with individual on-site or community systems. Strict state regulations protect SA shellfishing waters; hence there is a low probability that new surface discharges will be allowed. Surface discharges may be approved, however, if areas currently designated SC can be shown to have sufficient assimilative capacity to handle additional effluent and adjoining SA waters would not be affected by the new discharge.

Land availability on barrier islands is a major constraining factor for large spray disposal sites. Generally, local property owners are unwilling to pay the total cost of centralized facilities requiring mainland disposal sites or ocean outfalls. In addition, northern communities above Cape Lookout would almost certainly use soil absorption because of the long distance to the mainland. Southern barrier island communities may still find mainland disposal a viable alternative, depending on land and effluent transmission costs. The ocean outfall option still exists, but the cost of individual community financing of this disposal alternative appears to be prohibitive.

Regional treatment systems are improbable without federal funding. Adjacent communities must view their wastewater treatment needs as similar in order to consider the coordinated arrangements necessary for a regional system. In addition, the capital costs of a regional system must be supplied by the local population, many of whom may view the expense as unnecessary since their existing systems are adequate.

However, a regional system using an ocean outfall may be considered in the Dare Beaches area. Capital costs for collection, transmission, treatment, ocean outfall and sludge removal would be high. In all other areas, the low density of existing development and the high cost of regional systems precludes their use in the absence of federal funds.

If central and regional systems are not affordable then future development must rely on on-site and community systems. On-site systems would be used for individual homes and businesses and would be selected to match the proper soil suitability. A broad array of soil absorption systems could be used, ranging from mounds to conventional septic tank/drain field configurations.

3.2.1 Continued

On lots which are unsuitable for using soil absorption systems, the increased use of alternative/innovative treatment systems, such as composting toilets, may be used. An alternative to individual innovative systems would be to join with other owners with the same problem and install a community system servicing several parcels.

Future development will probably use a greater proportion of community systems. Community systems allow waste treatment and disposal facilities to be placed on suitable sites away from dwelling units thereby permitting development of marginal lands. Also, as costs increase, multifamily structures could be built to keep costs as low as possible. These units will also use community systems.

Existing development will also require new technical solutions because existing wastewater treatment systems will occasionally fail due to improper installation, overuse or neglect. As renovation of existing systems proceeds, the failure rate should decline. Systems installed since 1977 are less likely to fail because state guidelines have been followed in siting and installing these newer systems.

In summary, if no additional EPA assistance is provided, the use of wastewater treatment systems on barrier islands over the next 20 years will probably be very similar to current practices. Local and state regulations will govern the use of soil absorption systems. Individual owners will be responsible for providing adequate treatment and will bear the cost of renovating faulty systems or installing new facilities on newly developed lands.

3.0 NO FEDERAL ACTION ALTERNATIVE

3.2 Future Development Scenario Without Further Federal Funding

3.2.2 Institutional Overview

EMPHASIS WILL BE PLACED ON MANAGEMENT BY INDIVIDUALS

The individual property owner will continue to be responsible for wastewater management systems. The effectiveness of the Coastal Management Program should not be impaired by the No Federal Action Alternative. However, without the incentive of federal funds, individual communities may be less likely to address water quality problems on a regional scale.

Management of on-site wastewater treatment systems will remain the responsibility of the property owner, including construction, operation, and maintenance. Local and state agencies will remain involved in the initial approval of on-site systems and the identification of problems and remedial measures. Sub-surface and surface discharge system operations will continue to be monitored by the Division of Environmental Management. No new local regulations are expected unless a centralized system is built necessitating sewer use ordinances or user charge regulations. However, the 1982 Ground Absorption Regulation now addresses maintenance of systems, i.e., systems which exceed 3,000 gallons per day and other systems which are required to be designed by a professional engineer shall be reinspected annually by the person owning or controlling the property.

Critical Areas of Environmental Concern (AEC) will remain under the protection of the Coastal Management Program, administered by the state and local governments. Lands outside the AEC must conform to local land use plans prepared under the Coastal Area Management Act. These development guides are not affected by EPA funding and would apply in the absence of federal monies.

Planning for integrated water quality management may be effectively eliminated without federal assistance. Currently, federal funds allow and encourage evaluation and planning among neighboring units of government to address water pollution problems that may be solved collectively. Loss of federal funding will encourage local communities to assess only their own problems, thus leading to local solutions which may overlook economies of scale available under multi-jurisdictional solutions.

Current and past regulations governing the siting of on-site soil absorption systems will affect future development patterns. These regulations were previously discussed in Section 3.2.

GREATER SHARE OF SYSTEMS COSTS WILL BE BORNE BY INDIVIDUALS

Costs for on-site and small community systems will be borne by individual property owners. Local governments will likely be significantly less involved financially in wastewater management services than if the draft 201 Plans were implemented.

Costs involved in supplying wastewater treatment facilities on barrier islands will be the responsibility of the property owner if further EPA assistance is withdrawn. This assumes that local governments will not construct central or regional treatment systems during the next 20 years except in unusual circumstances.

Without the assistance of federal funds, individual homeowners probably will not support regional or central systems that attempt to provide future benefits at the expense of current users. Generally, property owners will tend to reduce their sewage treatment costs by relying on existing systems.

In areas of existing development, home owners who experience individual problems will renovate the system in compliance with local health board mandates. The owner will bear all the costs associated with the renovation. In areas that experience general problems, there may be a movement toward a community system if land is available for disposal and the combined total system costs would be less than the total costs for renovation of all malfunctioning individual systems.

4.0 DESCRIPTION OF ALTERNATIVE PROCEDURES DEVELOPED BY THE EIS

SYSTEMS FLOWCHARTS OF PROCEDURES ARE SUPPORTED BY TEXT AND DIAGRAMS

Procedures are presented to supplement standard 201 planning requirements. These modifications respond to barrier islands' natural resource and socio-economic constraints.

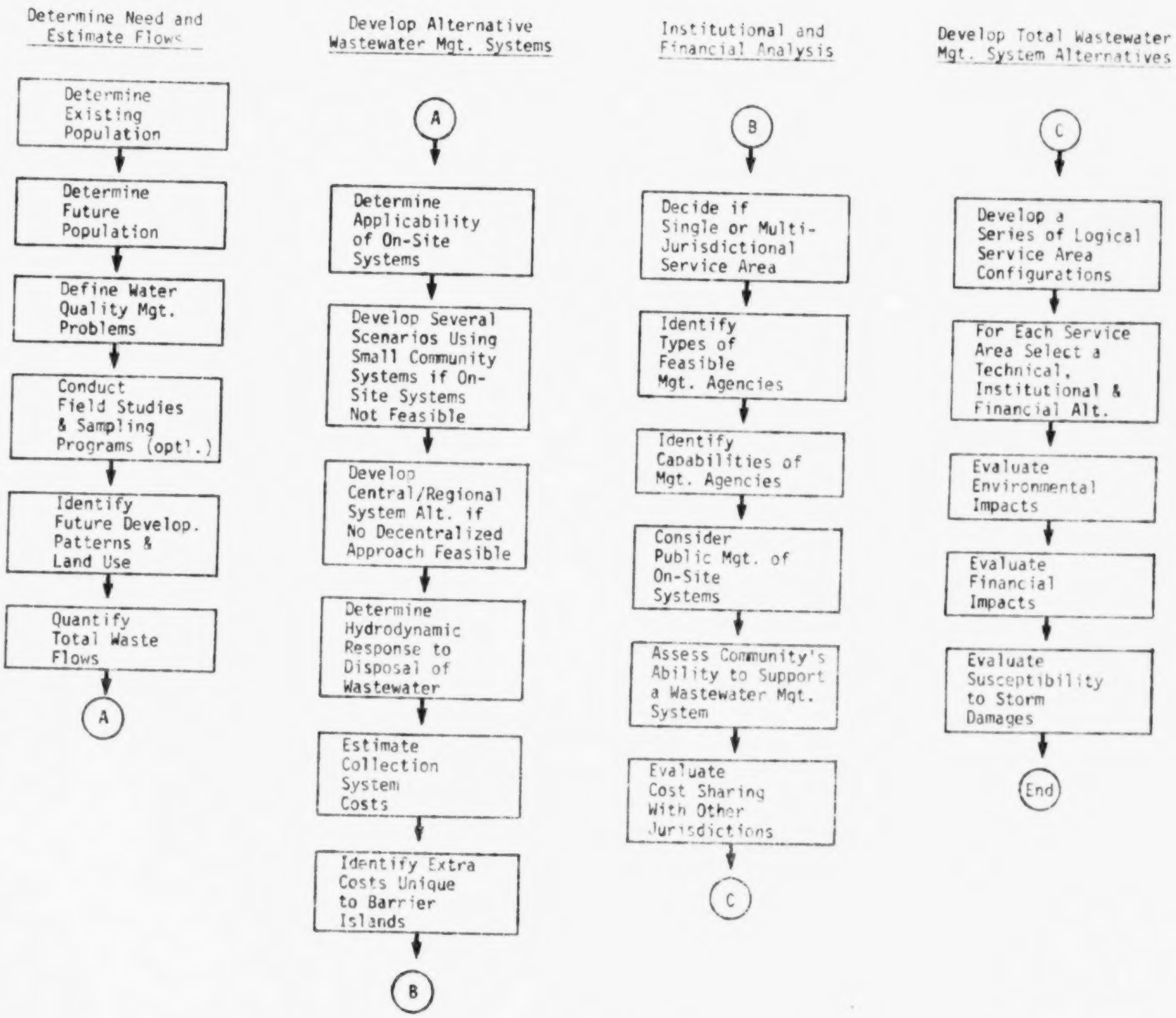
Procedures developed by this EIS are intended to supplement procedures normally undertaken in the preparation of a 201 Plan. These additional procedures are proposed in response to the needs of North Carolina barrier islands with extensive environmentally sensitive areas, highly fluctuating populations and limited financial resources.

The supplemental procedures fall into three major groupings and each is discussed in turn:

- Procedures for determining need and estimating flows
- Procedures for developing alternative wastewater management systems
- Procedures for evaluating alternative wastewater management systems.

An effort has been made to communicate these procedures in narrative and graphic form. Systems flowcharts are included with each section of text in order to present an overview of each methodology. Histograms, matrices and other diagrams are included where appropriate to provide maximum visual parallels to written materials. Figure 4.0 is a flowchart which presents an overview of the procedures discussed in this chapter.

A supplemental bibliography arranged by subject has also been included in the Appendix as a source of additional information on the subjects discussed in this report.



Determine Need and Estimate Flows
Determine Existing Population
Determine Future Population
Define Water Quality Mgt. Problems
Conduct Field Studies & Sampling Programs (opt'.)
Identify Future Develop. Patterns & Land Use
Quantify Total Waste Flows
A
Develop Alternative Wastewater Mgt. Systems
A
Determine Applicability of On-Site Systems
Develop Several Scenarios Using Small Community Systems if On-Site Systems Not Feasible
Develop Central/Regional System Alt. if No Decentralized Approach Feasible
Determine Hydrodynamic Response to Disposal of Wastewater
Estimate Collection System Costs
Identify Extra Costs Unique to Barrier Islands
B
Institutional and Financial Analysis
B
Decide if Single or Multi-Jurisdictional Service Area
Identify Types of Feasible Mgt. Agencies
Identify Capabilities of Mgt. Agencies
Consider Public Mgt. of On-Site Systems
Assess Community's Ability to Support a Wastewater Mgt. System
Evaluate Cost Sharing With Other Jurisdictions
C
Develop Total Wastewater Mgt. System Alternatives
C
Develop a Series of Logical Service Area Configurations
For Each Service Area Select a Technical, Institutional & Financial Alt.
Evaluate Environmental Impacts
Evaluate Financial Impacts
Evaluate Susceptibility to Storm Damages
End

Figure 4.0 Overview of EIS Strategy

4.0 DESCRIPTION OF ALTERNATIVE PROCEDURES DEVELOPED BY THE EIS

4.1 Procedures For Determining Need and Estimating Flows

POPULATION, LAND USE AND WATER QUALITY INTERACT TO ESTABLISH NEED FOR WASTEWATER MANAGEMENT

Procedures for quantifying existing and future population and water quality problem are described. Existing and future development in need of wastewater management are identified. Thereafter, methods to calculate eligible flows are explained.

Figure 4.1 graphically depicts the procedures required to determine the need for wastewater management systems and to quantify flows potentially eligible for funding under the 201 Construction Grants program.

Determining the need and estimating flows which require additional wastewater management consists of identifying those portions of existing and projected populations that cannot be adequately served by current wastewater management strategies. Essentially, population that cannot be adequately served by current wastewater management strategies is that population whose wastewater management strategies either cause water quality problems or will cause water quality problems when the population served increases.

The first step is to quantify existing population served by existing wastewater management strategies. This task tends to be difficult on the barrier islands because the resident population component is a small fraction of the summer peak which includes seasonal residents, overnight visitors and day visitors. Thereafter, projections must be made of these population components for five-year intervals during the planning period.

Having determined the existing population, the future population to be served must then be determined. This is accomplished by disaggregating the 1980 Census data for the study area and then calculating ratios of seasonal, overnight and day visitors to permanent residents. These ratios are then used with projections of the permanent residents to determine future population by component.

Next, procedures are discussed for pinpointing areas of existing development which are experiencing problems and are in need of new or improved wastewater management systems. This is accomplished by defining water quality problems and by inventorying actual conditions in the study area.

Future development patterns are determined by inventorying areas that can be used for future development in the study area. These areas will be lands on which CAMA has not restricted development, but the exact nature of the development of these lands will be affected by zoning and other plat restrictions.

Knowing or having calculated existing and future populations, existing development in need of wastewater management and future development patterns, total flows requiring wastewater management can be determined. Basically, this is accomplished by determining existing flows from either existing water

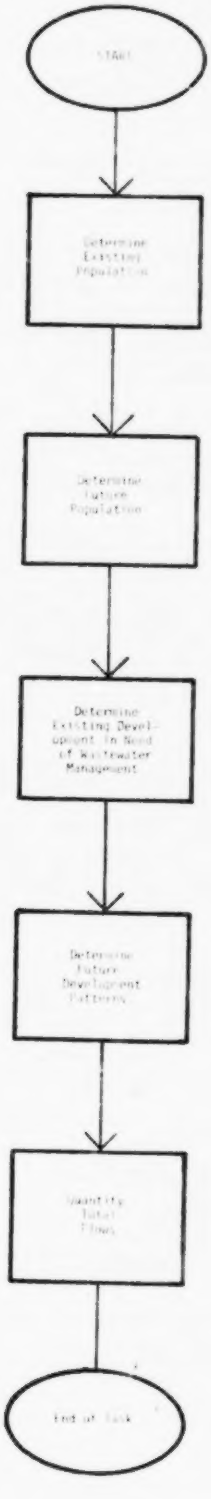

START
Determine Existing Population
Determine Future Population
Determine Existing Development In Need of Wastewater Management
Determine Future Development Patterns
Quantify Total Flows
End of Task

Figure 4.1 Methodology for Determining Need and Estimating Flows

Source: Claude Terry & Associates, Inc., 1981

4.1 Continued

use and existing wastewater treatment records or by multiplying population components by prescribed daily wastewater flow estimates. Similar ratios are then used for projecting flows for future developments. The total flow is then simply the sum of the current and future flows.

4.0 DESCRIPTION OF ALTERNATIVE PROCEDURES DEVELOPED BY THE EIS

4.1 Procedures for Determining Need and Estimating Flows

4.1.1 Procedures for Determining Existing Population

SEASONAL PEAK POPULATION IS MANY TIMES LARGER THAN
PERMANENT RESIDENTIAL BASE

Summer visitors complicate the tabulation of existing population. A methodology is presented which defines various population components and provides a process for calculating the number of permanent residents, seasonal residents, overnight visitors and day visitors.

For the barrier islands, obtaining accurate population information is complicated by large seasonal tourist fluctuations. During the winter months, the islands are populated by a small number of permanent residents and visitors. During the summer months, the islands' population greatly increases due to a large influx of tourists and seasonal residents. A ten- to twenty-fold increase is not uncommon. Therefore, in order to determine minimum and maximum wastewater flows, it is necessary to disaggregate the population into component parts and examine each component separately.

Four population components are identified for examination:

- Permanent residents
- Seasonal residents
- Overnight visitors
- Day visitors

In the following section, methods for estimating the size of these components at both peak periods and the off season are discussed.

Permanent Residents

OBERS Series E projections are the official estimates which are used by EPA as the basis for 201 planning for all Step 1 grants made prior to September 1978. At that time EPA published new population figures which have subsequently served as the basis for 201 planning. All six of the 201 Plans covered by this EIS were initiated prior to September 1978 and therefore used the OBERS figures. However, since EPA proposes to make additional Step 1 funds available, barrier islands communities will use the newer set of EPA state-approved population figures.

The EPA population figures contain estimates at the county level; therefore, some computation is necessary to disaggregate these figures to the 201 planning area level if the state has not already done so. A ratio methodology may be employed. The following steps are necessary:

- Determine which census tracts comprise the 201 planning area.
- Consult U.S. Census figures for 1980 and determine the percentage of the county population which is represented by the census tracts in the 201 area.

4.1.1 Continued

- Multiply this percentage by the population projections developed per the county population to get the number of permanent residents in the 201 planning area.

Any large discrepancies between EPA state-approved figures and Census Bureau figures should be examined, although the 201 Plan must use the figures developed per Appendix A.

- Develop ratios between each census tract and the 1980 Census figure for the 201 planning area.
- Disaggregate to the census tract level the population figures derived per Appendix A by applying these ratios.

Seasonal Residents

Estimation of the current seasonal population may be based on a determination of the number of seasonally occupied structures and an estimation of their occupancy rates during the peak season and off season. A determination of the number of seasonally occupied structures can be made by taking the total number of housing units per census tract (from U.S. Census data) and subtracting the number of units known to be occupied by permanent residents. Information concerning permanent occupancy can be gained from an investigation of utility hookups, tax records, mail deliveries or local knowledge.

Estimation of the capacity of seasonally occupied houses may be obtained by examination of building permit and/or property tax assessment records which should indicate the number of bedrooms per house. The estimated maximum capacity can then be estimated as the number of seasonal dwelling units x the number of bedrooms/unit x 2 persons/bedroom. Where local realtors indicate that two persons/bedroom is too low, a higher figure may be used. The estimated maximum capacity figure may be modified to give an estimate of the peak seasonal population by applying an occupancy factor to the seasonal housing stock based on local records of rental property managers.

In order to estimate the number of seasonally occupied units that are in use during the off season, it will be necessary to examine service records such as utility hookups and mail deliveries during the winter months. The number of seasonal houses being serviced multiplied by the estimated capacity of these houses may then be used as an estimate of the number of people using seasonal houses during the off season.

Overnight Visitors

An estimate of the current peak overnight population may be based on a determination of the capacity of facilities which provide overnight accommodations. For wastewater flow considerations, hotels, motels and rooming houses should be distinguished from campgrounds. The capacities of these facilities may be determined per census tract by direct contact with the owners or operators of such facilities or by examining records relating to building permits.

4.1.1 Continued

Maximum overnight population may be assumed to be equal to the number of overnight units filled to their stated capacity. An occupancy factor should be applied to arrive at seasonal peak figures. Overnight population in the off season may be determined by contacting owners or operators for information concerning occupancy rates during the winter months.

Day Visitors

Accurately estimating the size of the day visitor population is a difficult task. Unlike the other population components considered so far, no facilities or institutions keep statistics relating to day use. Also, day use encompasses a variety of possible activities including visiting residents, beach use, fishing, hiking, employment and shopping. Thus, there are no natural congregation points where day visitors could be counted.

In addition, factors such as ease of access to the island and proximity to nearby urban areas off the island will have a great influence on the size of this population component. For example, the amount of day use is probably less significant on the Outer Bank islands (Hatteras, Ocracoke), which are far from the mainland and urban population centers, while day use of beaches in New Hanover County, which are very close to Wilmington, is probably quite significant.

If day users are thought to have a large effect on wastewater flows, quantification of this component will have to be undertaken by local authorities. In general, quantifying the day visitor component will involve making an estimate of the total number of people on the island during peak periods and then subtracting known population components from the overall total with the remainder assumed to be day visitors.

However, estimating the total number of people on the island(s) at any given time is a difficult task subject to large errors. Probably the most precise method would be one based on traffic counts combined with origin/destination surveys conducted at bridges and ferry crossings leading to the island(s). In order to determine the number of day visitors using the islands during the off season, similar traffic counts and surveys could be conducted during the winter months.

Figure 4.1.1 is a flow chart showing the methodology described above. For seasonal residents and overnight visitors, an occupancy factor is used to modify the maximum figure for each population component to a smaller figure. Depending upon the occupancy factor selected by the user, the component computed can represent either a daily peak, a monthly peak average or an off season estimate.

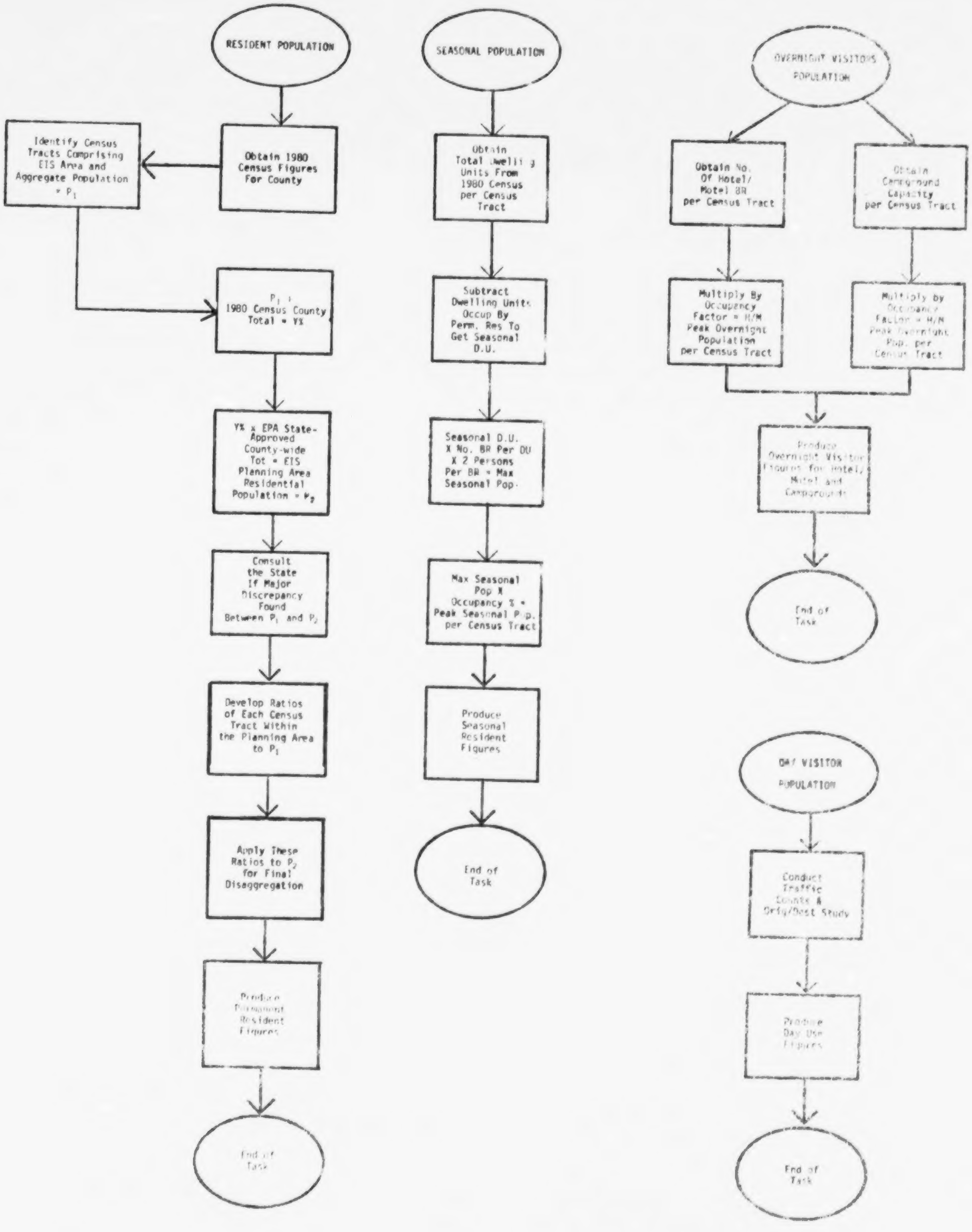

RESIDENT POPULATION
Obtain 1980 Census Figures For County
Identify Census Tracts Comprising EIS Area and Aggregate Population = P_1
P_1 ÷ 1980 Census County Total = Y%
Y% x EPA State-Approved County-wide Tot = EIS Planning Area Residential Population = P_2
Consult the State If Major Discrepancy Found Between P_1 and P_2
Develop Ratios of Each Census Tract Within the Planning Area to P_1
Apply These Ratios to P_2 for Final Disaggregation
Produce Permanent Resident Figures
End of Task
SEASONAL POPULATION
Obtain Total Dwelling Units From 1980 Census per Census Tract
Subtract Dwelling Units Occup By Perm. Res To Get Seasonal D.U.
Seasonal D.U. X No. BR Per DU X 2 Persons Per BR = Max Seasonal Pop.
Max Seasonal Pop X Occupancy % = Peak Seasonal Pop. per Census Tract
Produce Seasonal Resident Figures
End of Task
OVERNIGHT VISITORS POPULATION
Obtain No. Of Hotel/Motel BR per Census Tract
Obtain Campground Capacity per Census Tract
Multiply By Occupancy Factor = H/M Peak Overnight Population per Census Tract
Multiply by Occupancy Factor = H/M Peak Overnight Pop. per Census Tract
Produce Overnight Visitor Figures for Hotel/Motel and Campgrounds
End of Task
DAY VISITOR POPULATION
Conduct Traffic Counts & Orig/Dest Study
Produce Day Use Figures
End of Task

Figure 4.1.1 Methodology for Calculating Existing Population

Source: Claude Terry & Associates, Inc., 1981

POPULATION PROJECTIONS MUST BE BASED ON PAST TRENDS AND CURRENT POPULATION COUNTS

Projecting future populations in rapidly expanding vacation/resort/retirement communities is a speculative process because the largest population components are derived from inexact data. Therefore, future populations will be calculated using a series of procedures based on existing census data, land use information and actual visitor counts.

The overall strategy for projecting future populations involves using existing data to:

- Determine recent trends in the growth of the permanent population
- Establish the existing ratio of the permanent population to the various seasonal population components
- Extrapolate these trends and ratios over the 20-year planning period

This ratio methodology assumes a growth pattern in which all components of the peak population maintain the relative proportions which existed in 1980. Thus, if it was estimated that the 1980 peak population of an area was comprised of 10 percent permanent residents, 60 percent seasonal residents, 15 percent overnight visitors and 15 percent day visitors, it is assumed that these relative proportions will exist throughout the planning period.

The usefulness of this assumption stems from the fact that it is based on existing data and thus can serve as a general point of departure for speculations concerning future developments on the barrier islands. This assumption also has drawbacks since the potential course of development could vary greatly from one decade to another and this, in turn, will affect the relative proportions of the various population components. In the subsequent discussion, the estimation of the various population components will first be examined using the existing ratio assumption. Then, a brief consideration of factors which may alter this assumption will be presented.

Permanent Population

Projecting the size of the permanent population is a relatively straightforward task. Under the existing ratio assumption, the following steps are required:

- Using U.S. Census data for 1980, determine the percentage of the county population which is accounted for by the 201 area
- Multiply this percentage by the EPA state-approved projections of the county population for the years 1990 and 2000
- Extrapolate mid-points in the data to develop figures for 1985 and 1995.

4.1.2 Continued

However, if the 201 area has been growing and will continue to grow at a rate faster than that of the surrounding county, it will be necessary to consult Census data from previous years in order to establish the magnitude of this trend. The percentages used to disaggregate the EPA state-approved figures should be increased accordingly. However, if the converse is true, and the planning area population is growing at a slower rate relative to the county population, the percentage should be adjusted downward accordingly.

Seasonal Residents

To use the existing ratio methodology to project the number of seasonal residents, the following steps are required:

- Use the 1980 estimate of permanent and peak seasonal residents to determine the ratio between these population components.
- Apply this ratio to the estimates of future permanent population for 1985-2000 to derive numbers of seasonal residents.

If it can be shown through the use of Census data that the ratio of seasonally occupied housing units to permanent residents has been rapidly increasing in recent years, it may be desirable to alter the projected seasonal/permanent resident ratios to allow for this trend.

Several interrelated factors can affect the seasonal housing market and must be considered in any projection of the seasonal resident population:

- The amount of developable land in the area
- The existing and planned infrastructure
- The marketing targets of area developers
- The overall growth and stability of the housing market
- The permitted density of future development.

These factors will vary among the different barrier island communities and thus greatly affect the size of future seasonal populations. Therefore, communities in a given 201 area should decide what types of development scenarios are possible and/or desirable within their locales. Based on these scenarios, assumptions concerning the size of future seasonal populations may be refined.

Overnight Visitors

To project the number of overnight visitors, the existing ratio method may be used as follows:

- Use 1980 estimates of permanent residents and peak overnight visitors to determine the ratio between these two population components.
- Apply this ratio to the estimates of future permanent residents in the years 1985-2000 to derive estimates of the future peak overnight use.

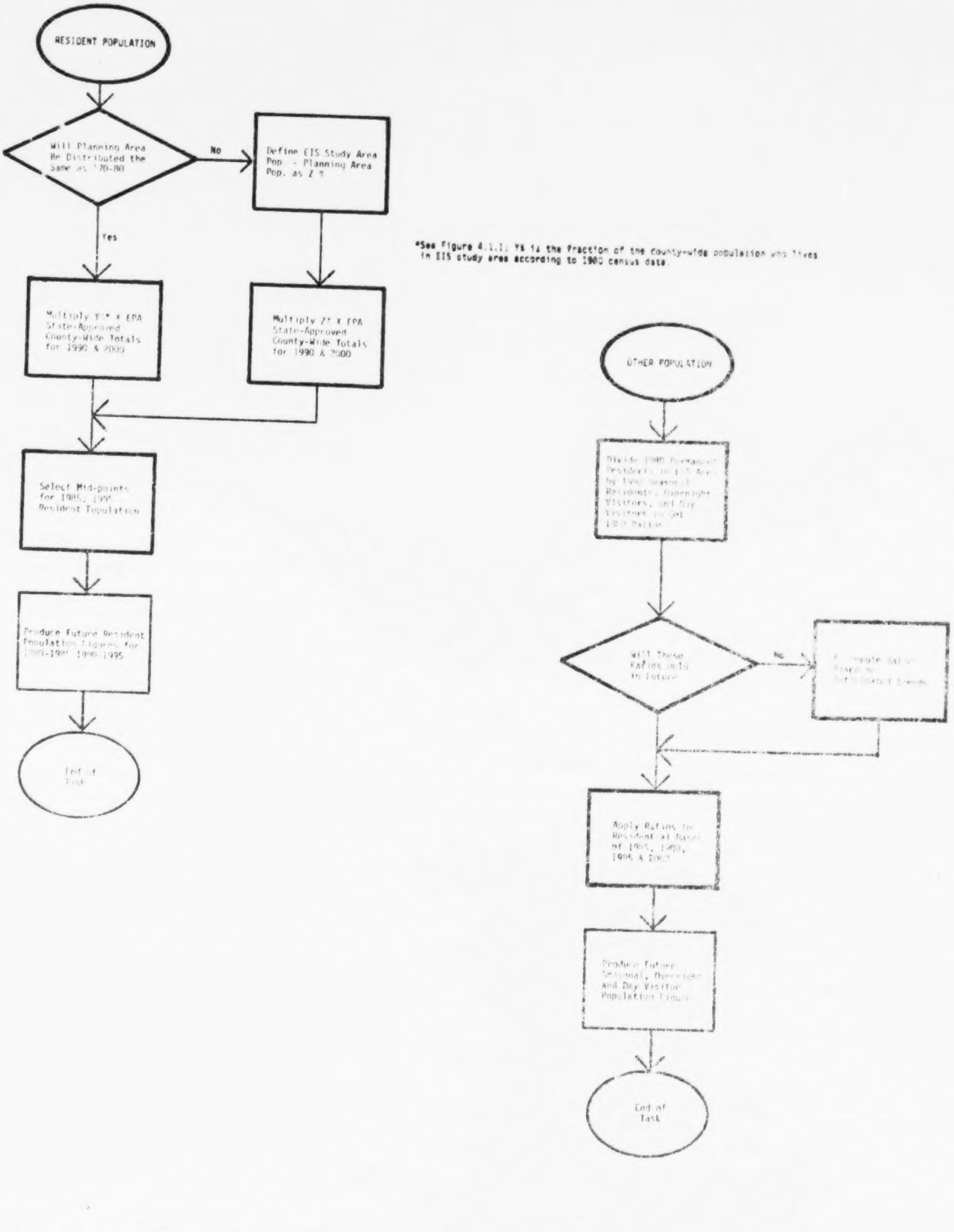
This approach assumes the continued attractiveness of the barrier islands as resort, convention or recreation areas. However, because of the relative remoteness of the islands, factors such as gasoline cost and availability may negatively influence overnight visitation. Also, because the natural environment of the islands is fragile, future population increases may result in adverse impacts on water, land and aesthetics which could reduce the appeal of the islands as places for recreation. On the other hand, improvements in access and community facilities may allow for the development or expansion of high quality resort hotels which could greatly increase overnight visitation. These factors should be kept in mind when evaluating projections of overnight visitation.

Day Visitors

Projections of day use may also be based on the existing ratio method by extrapolating the 1980 ratio of permanent residents to day visitors to the years 1985 - 2000. Since day visitation is heavily influenced by population trends on the nearby mainland, factors which may influence this population should be considered. Examples of such factors include new industrial developments or the closing of existing large facilities such as factories and military bases.

In summary, the projected total peak populations for the barrier islands may be estimated by adding together the estimates of the various population components. Projected off-season populations may also be calculated in similar fashion by using the existing ratio methodology. The methodologies described provide reasonable estimations of future populations based on existing data. Knowledge of local conditions should be incorporated in these projections whenever possible in order to yield more accurate predictions of the dynamic and complex population system which exists in the barrier islands.

Figure 4.1.2 is a flow chart showing the methodology described above.


RESIDENT POPULATION
Will Planning Area Be Distributed the Same as '70-80
No
Define EIS Study Area Pop. - Planning Area Pop. as Z %
Yes
Multiply Y%* x EPA State-Approved County-Wide Totals for 1990 & 2000
Multiply Z% x EPA State-Approved County-Wide Totals for 1990 & 2000
Select Mid-points for 1985, 1995 Resident Population
Produce Future Resident Population Figures for 1980-1985, 1990-1995
End of Task
OTHER POPULATION
Divide 1980 Permanent Residents in EIS Area by 1980 Seasonal Residents, Overnight Visitors, and Day Visitors to Get 1980 Ratios
Will These Ratios Hold in Future
No
Recompute Ratios Based on Anticipated Trends
Apply Ratios to Residential Bases of 1985, 1990, 1995 & 2000
Produce Future Seasonal, Overnight and Day Visitor Population Figures
End of Task

*See Figure 4.1.1; Y% is the fraction of the county-wide population who lives in EIS study area according to 1980 census data.

Figure 4.1.2 Methodology for Calculating Future Population.

Source: Claude Terry & Associates, Inc., 1981

4.0 DESCRIPTION OF ALTERNATIVE PROCEDURES DEVELOPED BY THE EIS

4.1 Procedures for Determining Need and Estimating Flows

4.1.3 Procedures for Determining Existing Development in Need of Wastewater Management

DOCUMENTATION OF EXISTING WASTEWATER MANAGEMENT PROBLEMS
IS ESSENTIAL

Wastewater management problems must be documented in areas of existing development. Documentation includes existing information, site inspections and field surveys. Evaluation of the performance of existing wastewater management systems establishes the framework for determining project need and improvements.

Existing development is defined as those structures presently built and generating wastewater. They may be identified either by consulting records in the Tax Assessor's Office or by aerial surveys. The Corps of Engineers presently conducts semi-annual overflights and makes available aerial photographs.

The first step in determining need for wastewater management systems to serve existing development involves a complete assessment of the area that claims to have a pollution problem and its relationship to the designated 201 service area. It is assumed that no need exists if such problems cannot be documented.

The assessment of need involves procedures for identifying pollution problems and their sources prior to determining if a wastewater management system can correct the problem. The procedures developed in the following sections include:

- Review of pertinent existing information
- Determination as to whether existing information can associate wastewater management with an existing pollution problem
- Collection of additional information via a site investigation and field study, if warranted.

Figure 4.1.3 presents an overview of the steps required to provide this documentation.

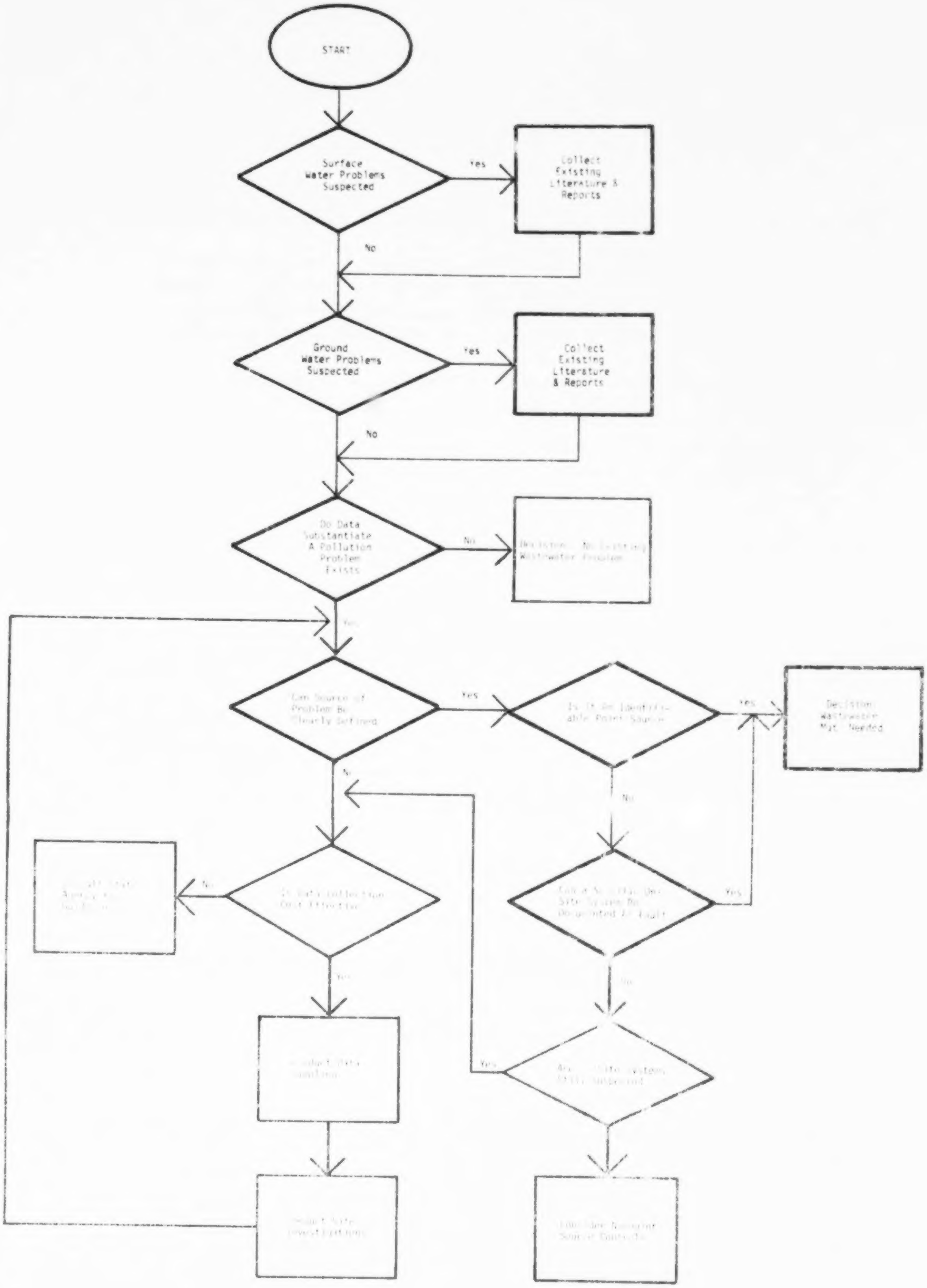

START
Surface Water Problems Suspected
Yes
No
Collect Existing Literature & Reports
Ground Water Problems Suspected
Yes
No
Collect Existing Literature & Reports
Do Data Substantiate A Pollution Problem Exists
No
Decision: No Existing Wastewater Problem
Yes
Can Source of Problem Be Clearly Defined
Yes
Is It An Identifiable Point Source
Yes
Decision: Wastewater Mgt. Needed
No
No
Is Data Collection Cost Effective
No
Can A Specific On-Site System Be Documented At Fault
Yes
Yes
No
Conduct Data Sampling
Yes
Are On-Site Systems Still Suspected
Conduct Site Investigations
Consider Nonpoint Source Controls

Figure 4.1.3 Methodology for Determining Existing Development in Need of Wastewater Management

Source: Claude Terry & Associates, Inc., 1981

4.0 DESCRIPTION OF ALTERNATIVES PROCEDURES DEVELOPED BY THE EIS

4.1 Procedures for Determining Need and Estimating Flows

4.1.3 Procedures for Determining Existing Development in Need of Wastewater Management

4.1.3.1 Definition of Water Quality Management Problems

WATER QUALITY PROBLEMS MUST BE DEFINED AS TO SOURCE AND MAGNITUDE

Water quality problems must be examined to define their source and the magnitude of the resulting impacts. Those problems related to wastewater management in the study area must be addressed by the facilities planning program.

The facilities planning process addresses two types of wastewater management problems:

- Existing problems that must be corrected
- Potential problems, resulting from growth in the area, that must be prevented.

Along the barrier islands chain, many sources of pollution could be causing water quality problems. Not all of these pollutant sources originate on the islands, nor are they all associated with wastewater management. The planning process must address the water quality problems to define their source and, for those related to wastewater management, to determine the frequency and magnitude of any detrimental impacts.

The planning procedure begins with gathering and reviewing pertinent data. Sources of information are listed in Table 4.1.3.1. The steps for the procedure are diagramed in Figure 4.1.3.1 and address the following:

- Groundwater quality (includes well water supplies)
- Estuarine water quality
- Shellfish closing reports
- Land use and soils characteristics
- Septic tank locations and operations
- Design details for existing and proposed wastewater management facilities
- Maintenance records on existing wastewater management facilities.

A review of the data gathered will determine if there are existing and, in some cases, potential water quality problems. Pollution problems that may occur are summarized below:

- Surface water
- High fecal coliform bacterial counts causing closure of waters to shellfishing or to water contact sports
- Nuisance levels of aquatic vegetation and/or phytoplankton
- Nutrient, BOD_5, or toxic pollution in wastewaters discharged
- Fish kills due to acute toxicity, stressed fish populations due to chronic toxicity, or decreased diversity of organisms from lowered dissolved oxygen levels or toxics
- Septage percolate reaching the soil surface and running off to surface waters.

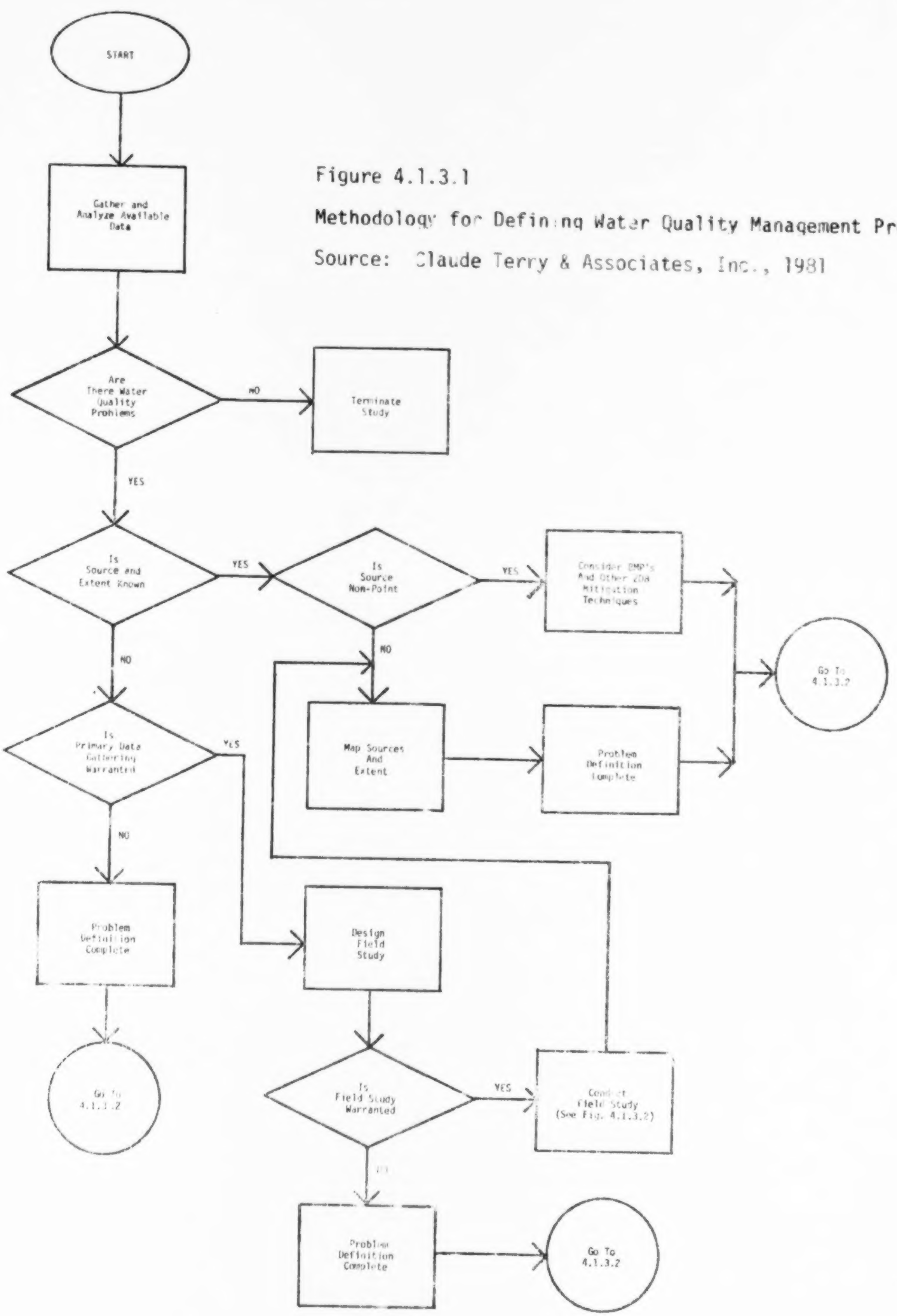

START
Gather and Analyze Available Data
Are There Water Quality Problems
NO
Terminate Study
YES
Is Source and Extent Known
YES
Is Source Non-Point
YES
Consider BMP's And Other 208 Mitigation Techniques
NO
Go To 4.1.3.2
NO
Map Sources And Extent
Problem Definition Complete
Is Primary Data Gathering Warranted
YES
NO
Problem Definition Complete
Design Field Study
Go To 4.1.3.2
Is Field Study Warranted
YES
Conduct Field Study (See Fig. 4.1.3.2)
Problem Definition Complete
Go To 4.1.3.2

Figure 4.1.3.1

Methodology for Defining Water Quality Management Problems

Source: Claude Terry & Associates, Inc., 1981

4.1.3.1 Continued

- Groundwater
- High nitrate levels
- High coliform levels
- Presence of synthetic compounds

It is assumed that if no pollution problems are noted, there is no need to do further analysis.

If a problem is identified, then the next step, determination of the source and extent, is made. To initiate this step, a review of potential causes is made that would include any one or all of the following causes:

- Natural high background concentrations
- Septic tank/soil absorption failures resulting from poor soil conditions, high density installation, inadequate design, mismanagement of operation and maintenance or improper administration
- Nonpoint source runoff from impervious surfaces in developed areas or from agricultural land use
- Point source discharge from municipal or industrial wastewater treatment plants
- Marina/vessel discharges
- Non-regulated industrial dumping such as by-products of fish processing plants
- Improperly designed/operated drinking water wells

If insufficient data exist to define the sources of water quality problems, it may be necessary to perform field investigations to accumulate the needed information. If it is cost-effective to obtain this primary data, then the investigator proceeds to field studies as noted on Figure 4.1.3.1. This procedure is described in detail in Section 4.1.3.2.

With or without a field study, all facts, judgements and uncertainties resulting from available information must be combined with 201 planning requirements and documented. 201 planning requirements include an evaluation of the performance of existing systems and how performance can be improved; development and evaluation of other wastewater management alternatives; a comparison of costs, impacts, operability and implementability for each alternative; and consideration of mitigative measures to reduce impacts of alternatives. More specific details of the 201 planning process are presented in the discussion of the 201 alternative (Section 2.0 of this report).

The next step in defining water quality management problems is deciding if problems are solely related to nonpoint sources and nonsanitary flows. These sources can include any of the following:

- Urban runoff and stormwater discharges
- Agricultural and vacant lands runoff
- Silvicultural and timber harvesting runoff
- Leachate from solid waste landfills
- Construction site runoff.

4.1.3.1 Continued

If the problem is determined as originating solely from nonpoint sources, then it is concluded that implementation of Best Management Practices (BMPs) is to be considered to control and mitigate the resulting detrimental impacts. When the pollution problem is determined to result from various point sources, then the final step for defining water quality management problems is undertaken if no ongoing program or requirements will correct the problem(s). An example of such a requirement would be an NPDES permit requirement for an industrial point source. This final step involves mapping of sources and quantification of contributions. Mapping of problem sources locates and evaluates the pollution origin and impact area. From this, patterns are determined and causes are identified. Some of these causes were listed previously in this section. With this information, existing development in need of wastewater management can be defined and documented to facilitate the development of viable wastewater management system alternatives.

Table 4.1.3.1 Available Information/Data Sources for Assessing Potential Pollution Causes.

	Type of Information/Data	Source of Information
Soil and Land Use	County soil surveys County land use plans and zoning maps	USDA, Soil Conservation Service County planning departments
	Special studies and records associated with septic tank/absorption field systems	EPA; N.C. Dept. of Natural Resources and Community Development, Div. of Environmental Management; N.C. Dept. of Human Resources; and local health departments
	Septic tank failure analysis via color/color infrared aerial photography	EPA Environmental Photographic Interpretation Center (EPIC)
Surface and Groundwater Data	Sanitary and bacteriological Surveys	County health departments; N. C. Dept. of Human Resources, Division of Health Services
	Monitoring data (general)	U. S. Geological Survey; N. C. Dept. of Natural Resources and Community Development, Division of Environmental Management; National Oceanic and Atmospheric Administration (NOAA)
	Special water quality studies	Universities and institutes
	Fisheries information	National Marine Fisheries Service; N. C. Dept. of Natural Resources anc Community Development, Division of Marine Fisheries.

Source: Gannett Fleming Corddry and Carpenter, Inc. 1981.

4.1.3.2 Procedures for Conducting Field Studies and Data Sampling Programs

FIELD STUDIES PINPOINT EXISTING POLLUTION SOURCES AND DEFINE EXTENT OF IMPACTS

Field studies are used to gather data on pollution problems to identify the sources of the problems and the magnitude and frequency of the resulting impacts. The studies should be designed to provide the required data at the minimum possible cost.

All too frequently, wastewater management decisions are made and implementation efforts undertaken without thoroughly reviewing whether the existing data provide any support for the action. In some cases, such decisions have been made in the absence of any supporting scientific data. However, it is mandatory that the cause of perceived pollution problems be traced.

An evaluation of the need for a field study is advisable in the following cases:

- Suspected failure of septic tanks leading to surface or groundwater pollution
- Suspected pollution of surface waters or groundwaters by permitted or unpermitted discharges
- Suspected pollution of surface or groundwater by nonpoint runoff.

In practice, it is frequently difficult to unequivocally demonstrate that a single factor, such as septic tank failure or water fowl excreta, leads to a water quality problem resulting in pollution. In these cases, establishing with scientific evidence the most probable causes of such problems must suffice.

Establishment of project need is dependent upon documenting the fact that pollution problems do indeed exist in the planning area. Therefore, once problems needing field studies have been defined, the initiation of field studies should be a very early activity. As field study results become available, they should be incorporated into the 201 planning process. The earlier the data results of the field study are available, the more confidence can be put in all subsequent planning activities. In too many cases, field studies have produced results too late to be of any use, or tardy sampling results have demonstrated that time and money have been wasted on developing and evaluating inappropriate alternatives.

Purpose of Field Studies

Establishing the scope of the field study is a critical early decision. The field study should be a series of investigations focused on specific perceived pollution problems. Factors to consider include size of the geographic area covered, sampling points, parameters to be sampled and sampling technologies. Criteria for conducting water quality studies can be found in several EPA publications (see Bibliography and Appendix A) and therefore are not discussed here.

Field studies for each perceived problem should be designed to:

- Demonstrate the cause-effect relationships between the purported caue project funds. Make sure that the data being collected are pertinent to each specific problem being investigated. Have a clear goal established as to the point of each investigation and periodically review each field study effort in view of this goal as the study progresses. Halt the study when the goal is achieved.
- Be completed in time to provide meaningful input to the 201 Study. Too often sampling program schedules are not well coordinated with the points at which information is needed by the 201 planning process.
- Be cost effective. If good experiential evidence is available that a problem exists, such as septic tanks overflowing or odor present, and remedial action is not overly expensive, remedies may cost less than an extensive data gathering program. However, when the proposed action involves large public and private costs extending over several decades, developing objective data is both logical and cost-effective, particularly if the data indicate a less expensive alternative is equally capable of resolving the problem.

During the planning and performance of each phase of a field study, cost-effective and time-effective analyses must be conducted to see if further pursuit of the remaining phases of the study is warranted. In many instances, the cost of the solution to a particular perceived problem in time and money may be less than the cost of a protracted investigation to prove the existence and extent of the perceived problem. Thus, further study would not be warranted.

Problem Definition and Study Design

The design of a field study consists of determining what series of specific perceived pollution problems exist and then determining the nature of the data required to trace each pollution problem to its source. It may be obvious that a problem exists; however, the current definition of the problem may be vague or too broad. At this point, the investigator is faced with the problem of actually doing part of a field study prior to having such data necessary to fully design the field study.

In actual practice, an iterative process of defining specific perceived problems and performing the field investigations necessary to define these problems must be undertaken. Usually the investigation necessary to perform this phase of defining specific perceived problems consists of a combination of researching available records and interviewing home and business owners and cognizant governing authorities regarding existing pollution problems. In the course of such investigations, leads to other problems will often surface. In other instances, suspected problems will be determined not to

4.1.3.2 Continued

exist. It is also possible that such an investigation will fully define the pollution problem as in the case of local health officials having fully documented a specific problem. In any event, persistence at this point will enable the investigator to begin to develop a list of specific suspected pollution problems. This list should remain dynamic throughout the study with problems being added or deleted as their existence is determined.

Once a list of perceived but unverified pollution problems has been prepared, a field study for each specific problem may be designed. The type of data that should be gathered will depend on where a pollution source exists or where the impact of the pollution exists. In the case of a septic tank overflowing into a stream, the field study is relatively simple... the documentation of an observation of the fact of the tank overflowing is sufficient to satisfy the requirements of the study.

However, defining the effects of the effluent of a soil absorption field on groundwater may require testing for fecal coliforms in adjacent water supply wells and from additional test wells. Most likely, the existence and location of this last type of pollution source will not be known, but the impact of the pollution will manifest itself (i.e., a closed shellfish bed). In this instance, a field test will have to be designed to investigate all potential sources of the offending pollution by first testing the surface water flowing in the vicinity of the closed shellfish bed to determine the direction from which the pollution is originating; then, further tests have to be devised on surface and groundwater to trace the location of the source. Investigations of this type can become expensive from both a cost and a time standpoint. In any event, the design of the study has to be specific to the needs required to trace the effect of the pollution or to trace the source of the pollution, reasons for failure and probable solutions.

As previously stated, the actual process of developing and conducting a field study is usually iterative between determining what is the actual field condition and in designing the next activity in the field study. The field study is also conducted in several stages which allow review of the process to determine if sufficient data have been collected or to determine if further study is warranted. The normal stages are outlined in the systems flow chart in Figure 4.1.3.2.

Site Investigations

Having defined the specific perceived problem through records review and interviews, site investigations are then usually required. A site investigation requires a visit to the sites where problems are reported to be occuring and an inspection of existing wastewater systems to see if they are designed and constructed properly and are being maintained adequately. Once the program is defined, a decision is made as to whether the investment of time and money for site investigations is warranted. If not, then the field study is complete. If at this decision point further studies are necessary, then the site investigation is conducted.

4.1.3.2 Continued

Detailed Field Study

After the site investigation, another decision point is reached. If the source and extent of the water quality problem and solutions can be defined, then no further field studies are required. If this is not the case and more information is needed, the next stage of the field study procedure is performed. This stage involves the design of a detailed field study. A well-conceived design should address the following study characteristics:

- Sampling period(s), frequency
- Geographic area to be sampled
- Field and laboratory measurements to be made and procedures to be followed
- Manpower and cost estimates
- Time to be allocated.

If such a study can determine the source(s) of a problem with sufficient certainty, it would be eligible for federal funding as part of the Construction Grants Program. Various detailed studies can provide useful short-term documentation of existing problems for surface and groundwaters. Examples include the following:

- Intensive, short-term water quality monitoring for physical, chemical and biological characteristics such as pH, dissolved oxygen, salinity, temperature, nitrogen species, phosphorus species, fecal coliform, BOD_5, productivity measurements, sediment analyses and/or a dye study
- A dye tracer study monitoring movement of effluent from an existing soil absorption field
- Aerial photos and photo interpretation to detect visual on-site system failures
- Monitoring of surface runoff during storm events.

Field and laboratory procedures for these studies which have been approved by EPA are available from various publications (see Bibliography).

Once the detailed field study is designed, the final decision point is reached: is the detailed study warranted? If not, then the study is complete; otherwise, the detailed field study is conducted to obtain all the necessary data. Each decision point of the field study procedures should be preceeded with the question: "Will the cost of the field work be justifiable based on what is expected to be discovered?"

The result of a complete field study should be a documented list of pollution sources that originate only from wastewater management problems, the quantity of the pollutant, the chemical and biological character of the pollutants and an explanation for the failure of the wastewater management systems to perform their function, as well as feasible solutions.

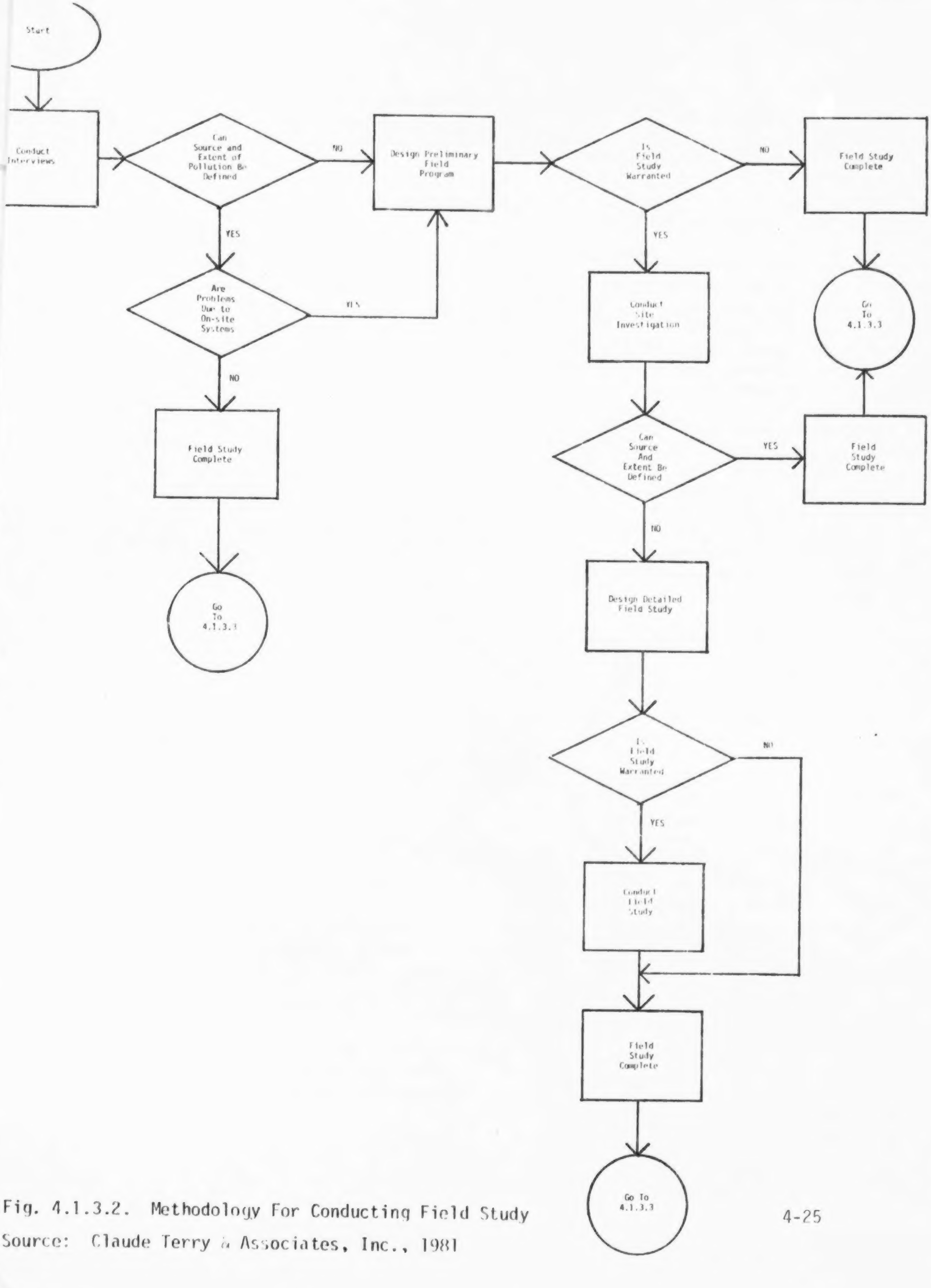

Start
Conduct Interviews
Can Source and Extent of Pollution Be Defined
NO
YES
Are Problems Due to On-site Systems
YES
NO
Field Study Complete
Go To 4.1.3.3
Design Preliminary Field Program
Is Field Study Warranted
NO
YES
Field Study Complete
Go To 4.1.3.3
Conduct Site Investigation
Can Source And Extent Be Defined
YES
Field Study Complete
NO
Design Detailed Field Study
Is Field Study Warranted
NO
YES
Conduct Field Study
Field Study Complete
Go To 4.1.3.3

Fig. 4.1.3.2. Methodology For Conducting Field Study

Source: Claude Terry & Associates, Inc., 1981

LANDS NOT PROTECTED BY CAMA HAVE DEVELOPMENT POTENTIAL

The initial task is to identify land which has development potential, with special consideration for lands classified by the Coastal Management Program as Areas of Environmental Concern. Thereafter, the location and density of future development must be established. Sources of information about future development are pinpointed.

The first step in identifying areas of future development that will require wastewater management services is to delineate areas which may be developed consistent with CAMA regulations. CAMA will permit development in Areas of Environmental Concern (AEC) if a permit is issued under the guidelines administered by state and local governments. A base map showing existing development in the 201 planning area should be prepared. AECs should be identified on it as areas which require conditional approval for future development. AECs are described in detail in the EIS Environmental Inventory Task Report, Section 3.6.1.4.5, and consist of:

- Estuarine waters
- Coastal wetlands
- Public trust areas
- Esturine shorelines
- Ocean erodible areas
- High hazard flood areas
- Inlet hazard areas
- Small surface water supply watersheds
- Public water supply wellfields
- Unique coastal geological formations
- Coastal complex natural areas
- Areas that sustain remnant species of flora or fauna
- Significant archeological resources
- Significant historic architectural resources.

Very low levels of development can be expected to occur in flood hazard and wave velocity zones as delineated on Federal Emergency Management Agency maps prepared as part of the National Flood Insurance Program. A recent tightening of regulations about insurability and increases in premiums may serve as strong disincentives to developers and homebuyers.

Given areas of developable land, the next step is to determine how much of that land will be developed during the design period. Location and density of development must be identified. The following sources of information should be consulted:

- CAMA Land Use Plans
- Zoning maps

4.1.4 Continued

- Platted lands maps
- Interviews with developers as to their intentions.

Figure 4.1.4 presents an overview of the procedures previously described and a preview of procedures to be discussed in subsequent sections.

The following sections describe each of these information sources and evaluate their ability to present consistent information for the 201 planning areas according to five criteria:

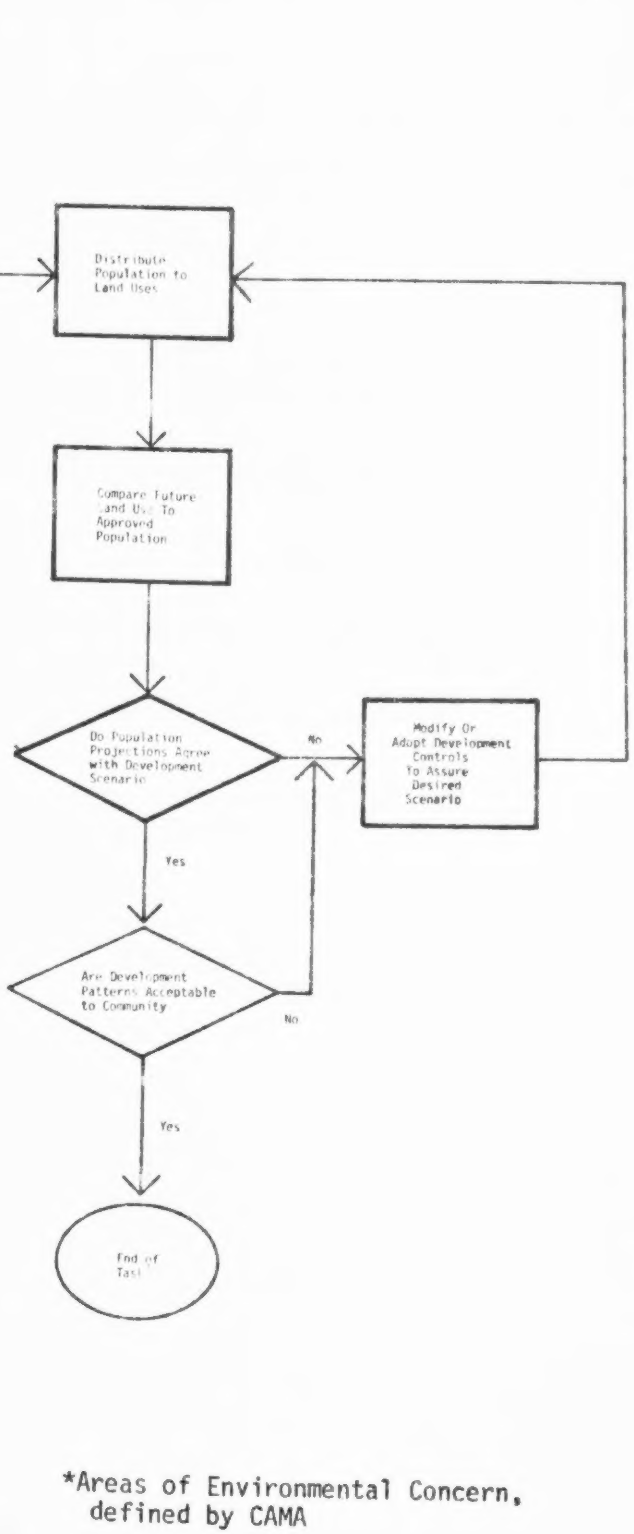
- Applicability: Does the mechanism defining the extent of development exist in each jurisdiction?

- Compatibility: Are the elements of each mechanism similar in each jurisdiction?

- Accessibility: How easy is it to obtain data from available sources?

- Consistency: Is the data based on the same time period or does one jurisdiction have 1975 data and another have 1980 data?

- Measurability: How accurate are the descriptions of development? Can the descriptions be quantified to give an accurate accounting of the level of development?



START
Obtain Base Map
Exclude Existing Development
Obtain CAMA Land Use Plans, Zoning Maps, Platted Land Maps
Note AEC's* as Needing Permits
Interview Developers
Compute Demand For Housing, Commercial & Recreation Land
Distribute Population to Land Uses
Compare Future Land Use To Approved Population
Do Population Projections Agree with Development Scenario
No
Modify Or Adopt Development Controls To Assure Desired Scenario
Yes
Are Development Patterns Acceptable to Community
No
Yes
End of Task

*Areas of Environmental Concern, defined by CAMA

Figure 4.1.4 Methodology for Identifying Future Development in Need of Wastewater Management

Source: Claude Terry & Associates, Inc., 1981

FUTURE LAND USE PLANS: UNQUANTIFIABLE FUTURE

CAMA future land use plans indicate that all available non-sensitive areas will be developed. The plans are not site specific, however, and the land classifications do not identify discrete land uses.

The Coastal Management Program (CMP) future land use plans show areas for transitional, rural, community, developed and conservation classifications. These classifications define general objectives for each area that relate to the intensity of use envisioned to occur over the next five years. Policies are designed to guide growth in developed areas and restrict growth in conservation areas. Generally the classifications are:

Transition:	medium density development expecting intensive growth
Developed:	medium to high density development
Rural:	areas where no significant growth is expected
Community:	existing built-up/incorporated areas showing low intensity development
Conservation:	restricted development

Land Use Plan Analysis:

Applicability: Land use plans have been developed for all barrier islands. The plans cover all areas above mean high water and thus present uniform coverage for the entire study area.

Accessibility: Copies of the land use plans are readily available from each local jurisdiction as well as from the Office of Coastal Management in Raleigh and at four field offices in the coastal region.

Measurability: Each land use plan uses five land use classifications to indicate appropriate levels of use for general geographic areas. The classifications are intended to designate areas suitable for development and give very broad descriptions of the expected development level. For example, Community Lands are described as: "**Community lands:** Which include areas capable of low intensity residential development. Public services and utilities in these areas will be available at a lower level than in the developed and transition lands." There is no reliable methodology to quantify "low intensity residential development" and other such general terms used in the land use plan. Therefore, any estimates of the size of development would be subjective.

4.1.4.1 Continued

Compatibility: The land use plans are totally compatible from island to island in their development process, their descriptions of land use and their administration procedures.

Consistency: Updates of the CMP land use plans are carried out on a five year rotating schedule. Although plans from neighboring areas may be due in different years, once the updates are approved, all plans will have the same standing in the context of the five year update process. Also, due to the use of general classifications, the revisions usually address policy rather than actual changes in areal extent of classified lands. This fact results in plans that are static in form but dynamic in implementation within each land classification.

Conclusion: The Coastal Management Program land use plans provide a comprehensive policy framework addressing long range goals of the state and local governments throughout the barrier islands. However, due to their general classification system and the lack of any quantifiable figures detailing land use, building densities, or population, it would be impossible to extract reliable baseline data for 201 planning purposes.

While these five designations express the desires of the community towards allocating future growth, there are no definitive ways of measuring when the growth will occur. Yet the land use plans do present an overview of all the barrier islands and their future development. Furthermore, the plans all use the same parameters for defining each level of land use. This allows the same assumptions to be used for all jurisdictions.

ZONED LANDS: INCONSISTENT COVERAGE AND CLASSIFICATION

Zoning has not been adopted in all barrier island communities. Discrepancies between similar classification categories make cross jurisdictional comparisons difficult.

Zoning ordinances provide development guidance, essentially regulating the land and its structures. Uses are defined and mapped according to zoning district, therefore implying types of use and levels of density to the community. However, four of the eight oceanfront counties do not administer zoning ordinances, thereby limiting their use as a means of quantifying future development. Also, the standards used to define use categories often vary among jurisdictions, creating problems with compatibility.

Zoning Ordinances Analysis:

Applicability: Communities such as Nags Head, Kill Devil Hills and Long Beach have adopted zoning ordinances. Others have not instituted this land use mechanism, creating discontinuous coverage of barrier island jurisdictions.

Accessibility: Detailed zoning ordinances and maps are available from all communities that have adopted zoning.

Measurability: Each zoning ordinance defines a particular use for each zone. The zoning map shows the extent of each zone thereby allowing calculations of probable intensity of use. These calculations would be based on many assumptions, however. For instance, minimum setback standards are established for each lot yet there is no restriction on the maximum size of a lot. If calculations were predicated on minimum dimensions, they would tend to exaggerate the actual density. Also, zoning classifications do not consider when development will occur. A large tract of land could be classified as multifamily, with a large population anticipated when it is finally developed, but if development does not proceed, then using the zoning classification will give a distorted picture of actual events.

Compatibility: Among those jurisdictions administering zoning ordinances, there are differences in land use classifications which present the problem of coordinating dissimilar criteria. To remedy these discrepancies would require modifications to existing ordinances, adherence to an official ordinance, or a comparison of specific categories that had the approval of all communities. These options would be very difficult to implement.

Consistency: Consistency in timing among jurisdictions would require a sign-off from each entity that it had satisfactorily completed its zoning of all lands.

4.1.4.2 Continued

Conclusion: Zoning ordinances attempt to establish community standards for development. These rules and regulations provide guidance for the relationships among neighboring uses and imply a level of land use within delimited districts. The actual level of use is difficult to judge, however, because all the land is not developed and current uses may exceed the minimum requirements.

4.1.4.3 Platted Land Maps

PLATTED LANDS: POTENTIAL DEVELOPMENT WITHOUT A TIME FRAME

Many areas of the barrier islands have been subdivided and platted to accommodate continuing growth. Many parcels have been sold, but some owners have not exercised their right to build.

Subdivision regulations are implemented by local governments to control the conversion of undeveloped real estate into developed parcels of land capable of supporting a particular intensity of land use. Thus, future land use density has been determined and will ultimately be realized if the owner can develop the area or sell the subdivided parcels to other individuals for their use. By inventorying the allowable type and extent of platted/subdivided lands, it is possible to compute the expected development impact within a community's jurisdiction. At any given time, however, there may be extensive acreages of subdivided lands available which have not been developed other than on paper.

Not all land owners have made their intentions known by recording plats, and some plats show lots that would be unbuildable under current community standards. These discrepancies could result in inaccurate projections of the level of development to be expected in coming years. Also, the rate of development of these lands is based on market forces and cannot be predetermined.

Platted Lands Analysis

Applicability: Land ownership is documented in all North Carolina barrier islands by the county tax assessor's office. If the land had been subdivided, an accurate record would be available and would correspond to deeds in any other location.

Measurability: Land parcels that are subdivided will show the number of lots under single ownership, therefore allowing a total number of developable lots to be calculated. Further investigation would be necessary to determine the level of use on each parcel, either present or intended use.

Accessibility: Public records in the tax assessor's office are available for inspection by the public. However, compiling and updating all records to the same level would be a difficult task since there are no centrally indexed platted lands directories.

Compatability: The information on platted lands would be compatible throughout all jurisdictions.

Consistency: The information available from the tax assessor's office is updated continually in each jurisdiction assuring that all records reflect

4.1.4.3 Continued

current land ownership patterns.

Two factors complicate the use of platted lands for determining future development. First, although the data available are from agencies throughout the area, an accurate tabulation of platted lands would require a detailed search of all individual land parcel records to establish the true extent of platted lands. At the present time no records are maintained on how many lots are platted in each jurisdiction. Second, although property may be subdivided for an implied use, there is no method for determining the ultimate level of use.

Conclusion: Records on platted lands provide an accurate picture of the future many landowners would like to see on the barrier islands. Large tracts of land have been subdivided and many parcels sold for new residential use. The problem lies in the fact that much subdivided land is either unsold or undeveloped and therefore considerable uncertainty exists as to the time frame of future development.

4.0 DESCRIPTION OF ALTERNATIVE PROCEDURES DEVELOPED BY THE EIS

4.1 Procedures for Developing Need and Estimating Flows

4.1.4 Procedures for Determining Future Development Patterns

4.1.4.4 Procedures to Integrate Information Sources

POPULATION PROJECTIONS FORM THE BASIS FOR FUTURE DEVELOPMENT SCENARIOS

Projected population figures must be translated into demand for housing, commercial and recreational land uses. These demands are then sited according to zoning maps, platted land maps and CAMA land use maps. Several iterations of the procedures may be necessary before a community agrees to a future scenario.

Putting together a map of future development between 1980 and 2000 is an iterative process which requires combining projected land uses with projected numbers of permanent and seasonal residents and overnight visitors. Questions to be answered include (1) where will these people be housed and (2) how much land will be required for support facilities (commercial, recreational).

Residential Land Requirements

Initially, compute the number of dwelling units required to house projected permanent and seasonal residents. 1980 Census data will provide a local occupancy factor (number of persons per dwelling unit) for the residential population component. Examination of local rental agency records will provide an appropriate occupancy rate for seasonal residents.

Now given the housing demand, the next step is to select areas which can accommodate this demand based on platted land, zoning maps and CAMA Land Use Plans. A knowledge of local markets will aid in selecting locations which will be developed during the next 20 years.

The demand for hotel/motel bedrooms and campgrounds can be derived from projections of overnight visitors. Examination of the records of local hotels and motels will give an appropriate number of persons per bedroom to be used in calculating demand for rooms. Room demand may thereafter be broken down into a number of hotels/motels based on the profile of typical local facilities' size range. The demand for campgrounds may be developed based on the prevailing local statistics of persons per acre. A knowledge of local conditions allows the tentative siting of new hotels and campgrounds in locations zoned accordingly. CAMA land use plans should be taken into consideration as well.

Commercial/Recreational Requirements

The demand for acres of future commercial and recreational land use may be projected from 1980 figures which reflect the ratio of existing residential land uses to existing commercial and recreational land uses. These demands can be tentatively sited on the future development map according to zoning districts and/or CAMA land use plans.

4.1.4.4 Continued

Procedural Biases

A bias inherent in the procedure above is the assumption that the community is willing to accommodate the total number of persons in the EPA state-approved projections. This assumption may be rejected once the community examines the future development map as initially drawn. Options include:

- Increasing zoning density so as to accommodate the state-approved projection on fewer acres
- Encourage redevelopment of existing parcels to accommodate increased density
- Adopt or alter zoning ordinances and other development controls to regulate densities according to community values.

Further iterations of the above procedures will produce a future development map which can be used for planning purposes with reasonable confidence. The map now shows areas of future development requiring wastewater management systems. Identification of appropriate systems is addressed in Section 4.2 of this report.

TOTAL FLOW IS TO BE BASED ON EXISTING AND PROJECTED POPULATION AND EMPLOYMENT FOR THE STUDY AREA

Sanitary flows should be developed based on four population categories. Process water flows should be based on commercial and industrial employment estimates for water--using establishments. Per capita and per employee wastewater generation rates are available based on national averages; however, characteristic usage in the barrier islands may differ.

The design (sizing) of any wastewater management facility, from on-site to regional systems, is based on the total flow that will be treated and the variability of that flow over the course of the year. Figure 4.1.5 presents an overview of the procedure for quantifying total flows.

EPA guidelines suggest using the Average Daily Base Flow (ADBF) for design purposes; however, the high variability of flows over the year in the barrier islands demands a more detailed analysis of flow characteristics to define ADBF for each season and for peak weekends (including holidays). The procedure used to determine flow characteristics is based on population and employment data that are generally available or can be developed. Four categories of population are used in the procedure as defined in Sections 4.1.1 and 4.1.2. Employment data are also required for those commercial and industrial activities that generate process water flows.

Variability factors for each population and employment category must be determined before flow estimates can be made. The degree of variability differs for each category as shown in Table 4.1.5-a. Once population estimates are developed, per capita flow factors can be used to generate the sanitary wastewater component for each category. Per capita flow factors can be developed using available data or by conducting field studies as described in Table 4.1.5-b. If site-specific data cannot be obtained, then literature values can be used. EPA suggests using 227-365 liters per capita per day (lpcd) (60-70 gpcd) for non-SMSA cities and towns with projected total resident populations of 5,000 or less; and 246-303 lpcd (65-80 gpcd) for other cities and towns. (Appendix A, 40 CFR Pasrt 35). Lower flows are suggested for seasonal residents and overnight and day visitors.

Based on the EPA-suggested per capita rates and the identification of water use by activity listed in Table 4.1.5.1-b, per capita rates have been developed for each population component. Table 4.1.5-c presents these suggested rates. These per capita rates have been developed strictly from secondary source data and should be used only when other data cannot be gathered.

Commercial flows are generated by restaurants, gas stations, grocery stores and hotels/motels, to name a few. These flows may be process or clean-up waters. Studies have been conducted in urban areas to develop unit

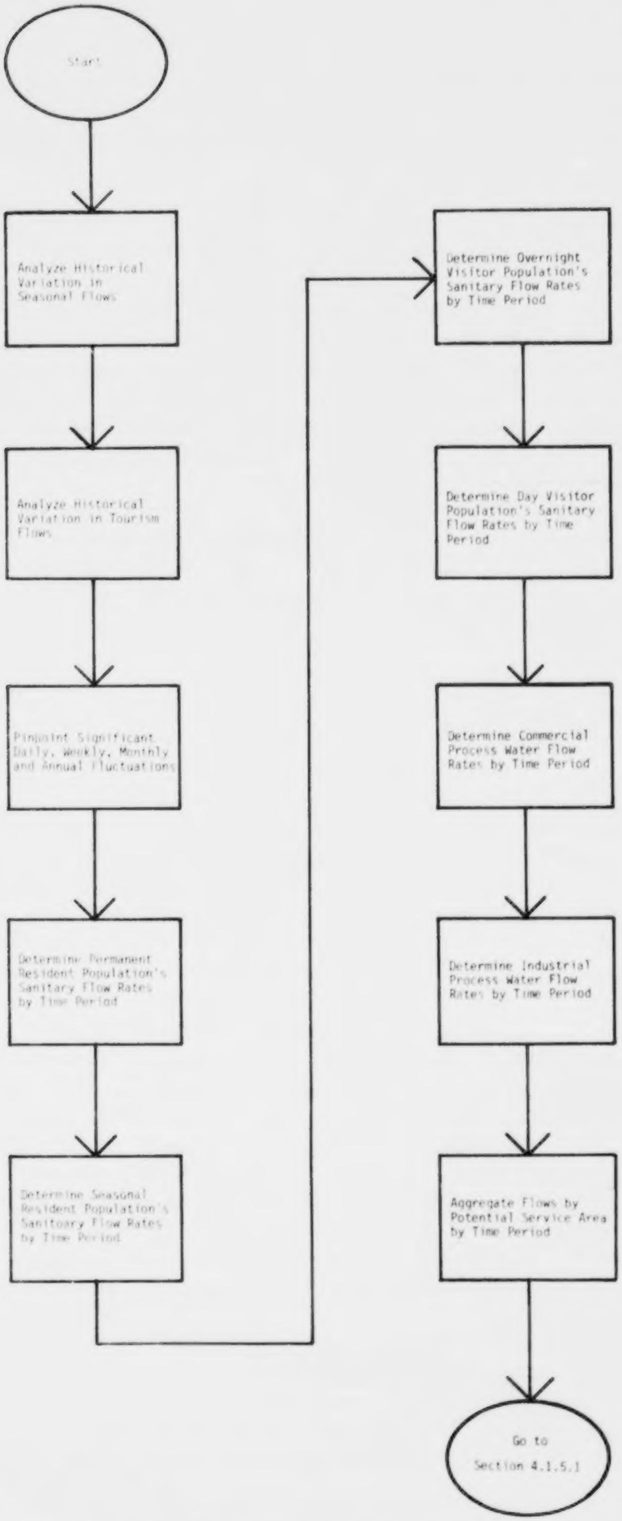

Start
Analyze Historical Variation in Seasonal Flows
Analyze Historical Variation in Tourism Flows
Pinpoint Significant Daily, Weekly, Monthly and Annual Fluctuations
Determine Permanent Resident Population's Sanitary Flow Rates by Time Period
Determine Seasonal Resident Population's Sanitoary Flow Rates by Time Period
Determine Overnight Visitor Population's Sanitary Flow Rates by Time Period
Determine Day Visitor Population's Sanitary Flow Rates by Time Period
Determine Commercial Process Water Flow Rates by Time Period
Determine Industrial Process Water Flow Rates by Time Period
Aggregate Flows by Potential Service Area by Time Period
Go to Section 4.1.5.1

Figure 4.1.5 Methodology for Quantifying Total Flows

Source: Gannett Fleming Corddry and Carpenter, Inc., 1981.

4.1.5 Continued

flow rates for commercial activities based on employment or other descriptive factors such as seating capacity for restuarants. If commercial enterprises' water usage is metered, it is possible to conduct a field study to determine specific wastewater flow generation rates. If metering is not done, or if the costs of a field monitoring program are too great, then standard flow factors can be used. It is important to realize, however, that the flow estimates derived from the population categories account for all sanitary wastewater flows, regardless of the source, unless there is a major employer in the study area (such as governmental offices) whose employees generally come from outside the area. It is necessary to carefully evaluate what flows are counted when calculating commercial flows so that when flows by population categories are figured, flows included in the commercial figures are not double counted. An example of this would be in the case of where day visitor's flow contribution is calculated in flows from restuarants. In this instance there will probably not be any flow by population category for day visitors to be considered since most of their total flow contribution will be part of commercial flows.

Industrial flow sources in the barrier islands are not numerous and should be individually identified in any facilities planning effort. EPA requires letters of intent to the grantee from the significant industries to document reserve capacity needs for existing and projected flows. EPA guidelines limit a Step 3 building grant assistance to a 20-year reserve capacity if the building grant is received after December 28, 1981, but before October 1, 1984. After September 30, 1984, no grant shall be made (except for the remaining segments of an initial segment granted before October 1, 1984) to provide reserve capacity for a project for secondary or advanced treatment or new interceptors and appurtences. Grants for such projects shall be based on capacity necessary to serve existing needs (including residential, commercial, industrial and other users) on the date of the grant approval but in no cases greater than existing needs on October 1, 1990.

Table 4.1.5-a Population Variability.

Category	Variability	Estimating Guide
1. Permanent Residents	Does not vary over course of the year.	Population estimates are adequate.
2. Seasonal Residents	Seasonal fluctuation. Use monthly estimates to define.	Housing capacity and rental records provide needed data.
3. Overnight Visitors	Seasonal fluctuation. Use monthly estimates to define.	Hotel/motel, boarding house, and campsite capacity and rental records provide needed data.
4. Day Visitors	Seasonal and daily fluctuations. Use daily or weekend/weekday estimates to define.	Traffic surveys, ferry records, beach-user interviews and other field surveys must be conducted to define adequately.

Source: Claude Terry & Associates, Inc. 1981.

Table 4.1.5-b Development of Per Capita Wastewater Generation Estimates.

A. Data Gathering

1. Primary Source Data
    a. Monitor water supply flows at selected locations (Public/Private)
    b. Monitor wastewater flows at selected locations (Public/Private)
    c. Develop information for peak periods
        - monitor on holidays
        - monitor on weekends
        - monitor on off-season
    d. Monitor permanent and seasonal residents to determine differences in water and wastewater utilization
    e. Survey employers to determine number of employees per visitor

2. Secondary Source Data
    a. Review existing water supply information
    b. Review existing wastewater information
    c. Review available pumping capacities and records for water and wastewater
    d. Review information on existing wastewater facilities
    e. Review employment/unemployment records to determine variations in work force
    f. Review resort visitor records

B. Data Reduction
1. Determine the extent and consequences of water conservation programs
2. Evaluate seasonal variations at selected locations
3. Evaluate different size and type facilities to determine wastewater generation differences
4. Identify peak and low flow periods (holidays, weekends, and off-season)
5. Evaluate public and private well pumping and capacity information
6. Evaluate water used that does not enter the wastewater stream (lawn sprinkling, car washing, etc.)

C. Estimation Procedures

1. Per capita flows
    a. Consider flow reduction efforts
    b. Use population information to determine wastewater generation
    c. Use employee information to determine wastewater generation for employees
    d. Select representative flows for population components
    e. Calculate per capita flows for each identified population component
2. Seasonal variation factors
    a. Develop peak and low flow factors with population information
    b. Develop factors for various population components and time periods
    c. Calculate desired seasonal flows with variation factors

Source: Gannett Fleming Corddry & Carpenter, Inc. 1981.

Table 4.1.5-c Per Capita Flow Rates by Population Category.

Category	Primary Use Characteristics	Flow Range	
		lpcd[1]	gpcd[2]
Permanent Residents	Toilets, bathing, dishwashing, clotheswashing	227-365	60-70
Seasonal Residents	Same as permanent residents	227-365	40-50
Overnight Visitors	Toilets, bathing	152-190	30-40
Day Visitors	Toilets	38-76	10-20

[1] Liters per capita per day
[2] Gallons per capita per day

Source: USEPA, Region IV 1982.

4.0 DESCRIPTION OF ALTERNATIVE PROCEDURES DEVELOPED BY THE EIS

4.1 Procedures for Determining Need and Estimating Flows

4.1.5 Procedures for Quantifying Total Flows

4.1.5.1 Procedures for Quantifying Flow and Waste Reduction Impacts

FLOW AND WASTE REDUCTION METHODS MUST BE EVALUATED

EPA-funded 201 wastewater facilities plans must evaluate flow and waste reduction and estimate the potential costs and benefits. Certain communities are exempted from these procedures. North Carolina state building code requires all new development to incorporate water conservation measures.

EPA-mandated procedures require 201 Plans to include an evaluation of alternative flow and waste reduction measures, including non-structural methods. Planning areas are exempted if the average daily base flow is less than 265.3 lpcd (70 gpcd), the current population is less than 10,000, or the EPA Regional Administrator exempts the area for already having an effective flow reduction program. However, the state building code requires that all new development after April 1980 install water saving toilets and shower heads. Facilities Plans must include:

- A public information program to encourage wastewater reduction
- Changes in water pricing policies to promote conservation
- Installation of water meters and retrofit with water-saving devices of existing homes and other buildings
- Changes in local ordinances or codes that require installation of water-saving devices in new homes or other buildings
- Allowance for reduced per capita rates for projected development.

Evaluations should include cost estimates of the proposed flow reduction measures and estimates of energy reductions and cost savings for wastewater treatment, water supply and energy use. The estimated flow reduction must be taken into account in the design of the proposed treatment works. Figure 4.1.5.1 diagrams the methodology for conducting this assessment.

All forms of conservation of water use will result in reduction of wastewater flows. Making the public more aware of the need to conserve water and the benefits for doing so has merit and will generally result in some savings. However, other forms of public motivation such as requiring users to pay for the actual amounts of water that they use will save even more. In particular, more careful use of water will result in savings when users are aware that they reap the rewards for doing so.

Water conservation methods are devided into three major groups as follows:

- Elimination of nonfunctional water use
- Water-saving devices, fixtures and appliances
- Wastewater recycle/reuse systems.

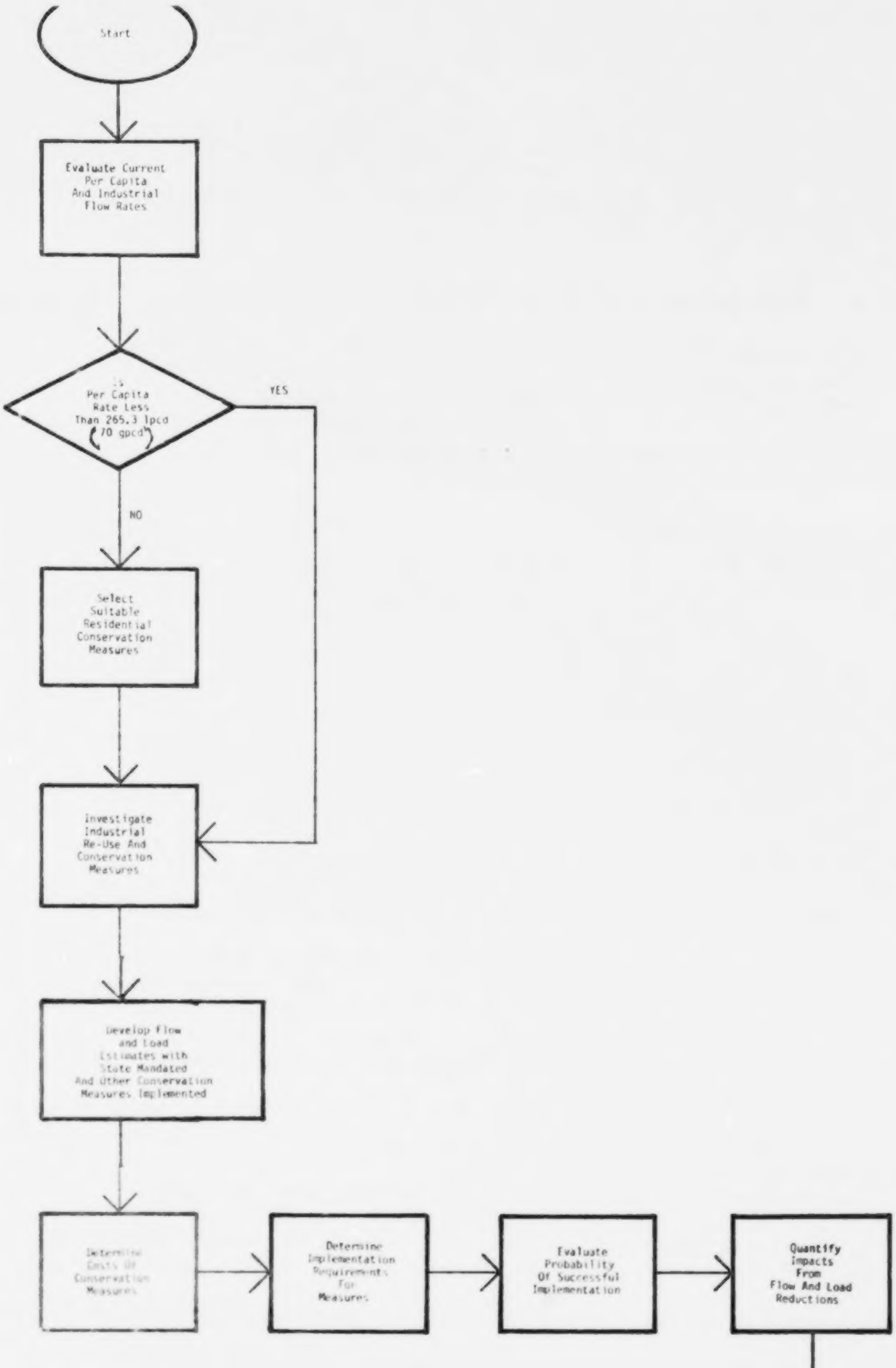

Start
Evaluate Current Per Capita And Industrial Flow Rates
Is Per Capita Rate Less Than 265.3 lpcd (70 gpcd)
YES
NO
Select Suitable Residential Conservation Measures
Investigate Industrial Re-Use And Conservation Measures
Develop Flow and Load Estimates with State Mandated And Other Conservation Measures Implemented
Determine Costs Of Conservation Measures
Determine Implementation Requirements For Measures
Evaluate Probability Of Successful Implementation
Quantify Impacts From Flow And Load Reductions
Go To 4.2

Figure 4.1.5.1 Methodology For Quantifying Flow and Waste Reduction Impacts

Source: Gannett Fleming Corddry and Carpenter, Inc., 1981.

4.1.5.1 Continued

Table 4.1.5.1-a is a summary of possible techniques for each water conservation method. It should be noted that non-water carriage toilets (composting, incinerating and chemical toilets) and recycle-reuse systems are addressed in Section 4.2 as viable treatment/disposal system alternatives. The other methods listed in the table are used only to reduce the wastewater flow generated and are not treatment/disposal system alternatives themselves. Another source of information on residential water conservation techniques is "Residential Water Conservation" by A. R. Rubin.

The mechanical or technical changes described by water conservation methods II and III of Table 4.1.5.1-a generally result in the most consistent savings. These devices are usually inexpensive, but some of them may be difficult to retrofit for older residences.

Wastewater segregation and some form of recycling without treatment is a concept of reuse that reduces wastewater flow volumes. This concept segregates the wastewaters into two categories, graywater (flows from clotheswashers, bathroom sinks, bathtubs) and blackwater (flows from toilets and garbage disposals). It is assumed that graywater is of a higher quality and can therefore be disposed of more easily or reused for purposes that do not require high water quality (such as toilet flushwater). Lately this assumption of relatively higher quality for graywater has been questioned and is subsequently being reconsidered.

Many wastewater flows generated in commercial or industrial facilities can be recycled through their production processes with minimal treatment. This may save a given industry far more in water costs and wastewater disposal costs than the cost of the installing and operating the treatment and recycling processes.

Since there is such an extensive array of water conservation techniques and devices available and of individuals' water-use habits, the estimation of potential flow reductions is difficult. For this study, the procedure to quantify reduced flow volumes will address only flows reduced using the conservation methods of groups II and III of Table 4.1.5.1-a. The success in reducing Group I's use is highly dependent on residents' existing habits, which are not easily evaluated and are subject to considerable variation without an effective monitoring and enforcement program.

Table 4.1.5.1-b is a breakdown of residential water use by activity. These figures are national averages and may vary from those of barrier island residents. Therefore, the first step in the quantification of potential flow reduction is to determine the estimates of water use by activity of the residents in the barrier island community being analyzed. If these estimates are not readily available, the national averages should suffice.

The second step is to determine which flow reduction techniques are suitable for the area and therefore have potential for being successfully installed. Once the potential flow reduction techniques are selected, the total flow reduction percentages for each technique may be completed. Examples are presented in Tables 4.1.5.1-c through 4.1.5.1-f.

Table 4.1.5.1-a Water Conservation Methods.

- I. Elimination of Nonfunctional Water Use
  - A. Improved water use habits
  - B. Improved plumbing and appliance maintenance
  - C. Nonexcessive water supply pressure

- II. Water-Saving Devices, Fixtures and Appliances
  - A. Toilet
    - 1. Water carriage toilets
      - a. Toilet tank inserts
      - b. Dual-flush inserts
      - c. Watersaving toilets
      - d. Very low-volume flush toilets
        - 1) Wash-down flush
        - 2) Mechanically assisted
          - Pressurized tank
          - Compressed air
          - Vacuum
          - Grinder
    - 2. Non-water carriage toilets (addressed in the invidual on-site treatment/disposal systems of Section 4.2, refer to Table 2 of Appendix D for descriptions.)
  - B. Bathing devices, fixtures and appliances
    - 1. Shower flow controls
    - 2. Reduced-flow showerheads
    - 3. On/Off showerhead valves
    - 4. Mixing valves
    - 5. Air-assisted low-flow shower system
  - C. Washing machines, fixtures and appliances
    - 1. Front-loading washer
    - 2. Adjustable cycle settings
    - 3. Washwater recycle feature
  - D. Miscellaneous
    - 1. Faucet inserts
    - 2. Faucet aerators
    - 3. Reduced-flow faucet fixtures
    - 4. Mixing valves
    - 5. Hot water pipe insulation
    - 6. Pressure-reducing valves

- III. Wastewater Recycle/Reuse Systems (Addressed in the individual on-site treatment/disposal systems of Section 4.2).

Source: USEPA. October 1980.

Table 4.1.5.1-b Residential Water Use By Activity.

Activity		Liter/use	Gal/use	Uses/cap/day	lpcd[1]	gpcd
Toilet Flush	mean	16.3	4.3	3.5	61.4	16.2
	range	15.2-19.0	4.0-5.0	2.3-4.1	34.9-75.8	9.2-20.0
Bathing	mean	92.9	24.5	0.43	34.9	9.2
	range	81.1-103.1	21.4-27.2	0.32-0.50	23.9-47.4	6.3-12.5
Clotheswashing	mean	142.1	37.5	0.29	37.9	10.0
	range	127.0-151.6	33.5-40.0	0.25-0.31	28.0-44.0	7.4-11.6
Dishwashing	mean	33.4	8.8	0.35	12.1	3.2
	range	26.5-47.4	7.0-12.5	0.15-0.50	4.2-18.6	1.1-4.9
Garbage Grinding	mean	7.6	2.0	0.58	4.5	1.2
	range	7.6-8.0	2.0-2.1	0.4-0.75	3.0-5.7	0.8-1.5
Miscellaneous	mean				25.0	6.6
	range				21.6-30.3	5.7-8.0
Total	mean				172.8	45.6
	range				156.9-197.1	41.4-52.0

---

[1] lcpd and gpcd may not equal volume multiplied by uses/cap/day due to difference in the number of study averages used to compute the mean and ranges shown.

Source: USEPA. October 1980.

Table 4.1.5.1-c Water Conservation Measures and Impacts on Wastewater Flows, Water Carriage Toilets.

Generic Type	Description	Development Stage[a]	Application Considerations	Water Use liters/event	Water Use gal./event	Total Flow Reduction		
						lpcd	gpcd	%
Toilet with Tank inserts	Displacement devices placed into storage tank of conventional toilets to reduce volume but not height of stored water. Varieties: Plastic bottles, flexible panels, drums or plastic bags.	4-5	Device must be compatible with existing toilet and not interfere with flush mechanism. Installation by owner.	12.5-14.4	3.3-3.8	6.8-13.3	1.8-3.5	4-8
Dual Flush Toilets	Devices made for use with conventional flush toilets; enable user to select from two or more flush volumes based on solid or liquid waste materials. Varieties: Many.	3	Device must be compatible with existing toilet and not interfere with flush mechanism. Installation by owner.	9.5-16.3	2.5-4.3	11.4-26.5	3.0-7.0	6-15
Water-Saving Toilets	Variation of conventional flush toilet fixture; similar in appearance and operation. Redesigned flushing rim and priming jet to initiate siphon flush in smaller trapway with less water. Varieties: many manufacturers but similar units.	5	Interchangeable with conventional fixture. Requires pressurized water supply.	11.4-13.3	3.0-3.5	10.6-17.4	2.8-4.6	6-10
Washdown Flush Toilets	Flushing uses only water, but substantially less due to washdown flush. Varieties: Few.	3-4	Rough-in for unit may be nonstandard. Drain line slope and lateral run restrictions. Requires pressurized water supply.	3.0-6.1	0.8-1.6	35.6-46.2	9.4-12.2	21-27

Table 4.1.5.1-c Continued

Generic Type	Description	Development Stage[a]	Application Considerations	Water Use liters/event	Water Use gal./event	Total Flow Reduction lpcd	Total Flow Reduction gpcd	Total Flow Reduction %
Pressurized Tank	Specially designed toilet tank to pressurize air contained in toilet tank. Upon flushing, the compressed air propels water into bowl at increased velocity. Varieties: Few.	3	Compatible with almost any conventional toilet unit. Increased noise level. Water supply pressure of 35 to 120 psi.	7.6-9.5	2.0-2.5	23.9-30.3	6.3-8.0	14-18
Compressed Air-Assisted Flush Toilets	Similar in appearance and user operation to conventional toilet; specially designed to utilize compressed air to aid in flushing. Varieties: Few.	3-4	Interchangeable with rough-in for conventional fixture. Requires source of compressed air; bottled or air compressor. If air compressor used, need power source.	1.9	0.5	50.4	13.3	30
Vacuum-Assisted Flush Toilets	Similar in appearance and user operation to conventional toilet; specially designed fixture is connected to vacuum system which assists a small volume of water in flushing. Varieties: Several.	3	Application largely for multi-unit toilet installations. Above floor, rear discharge. Drain pipe may be horizontal or inclined. Requires vacuum pump.	1.1	0.3	53.1	14.0	31
	Recycle total wastewater stream for all water uses	1-2	Requires major variance from state/local health codes for potable reuse Difficult to retrofit.			170.6	45.0	100

[a] 1 = Prototype developed and under evaluation.
2 = Development complete, commercial production initiated, not locally available.
3 = Fully developed, limited use, not locally available, mail order purchase likely.
4 = Fully developed, limited use, locally available from plumbing supply houses or hardware stores
5 = Fully developed, widespread use, locally available from plumbing supply houses or hardware stores.

Based on the normal waste flow information presented in Table 4.1.5.1-b.

Source: USEPA October 1980.

Table 4.1.5.1-d Water Conservation Measures and Impacts on Wastewater Flows, Bathing Devices and Systems.

Generic Type	Description	Development Stage[a]	Application Considerations	Water Use liters/min.	Water Use gal./min.
Shower Flow Control Inserts and Restrictors	Reduce flow rate by reducing the diameter of supply line ahead of showerhead. Varieties: Many.	4	Compatible with most existing showerheads. Installed by user.	5.7-11.4	1.5-3.0
Reduced-Flow Showerheads	Fixtures similar to conventional, except restrict flow rate. Varieties: Many manufacturers, but units similiar.	4-5	Can match to most plumbing fixture appearance schemes. Compatible with most conventional plumbing.	5.7-11.4	1.5-3.0
ON/OFF Showerhead	Small valve device placed in the supply line ahead of showerhead, allows shower flow to be turned ON/OFF without readjustment of volume or temperature.	4	Compatible with most conventional plumbing and fixtures. May be installed by user.		
Thermostatically Controlled Mixing Valve	Specifically designed valve controls temperature of total flow according to predetermined setting. Valve may be turned ON/OFF without readjustment.	3	May be difficult to retrofit.		
Pressure-Balanced Mixing Valve	Specially designed valve maintains constant temperature of total flow regardless of pressure changes. Single control allows temperature to be preset.	4	Compatible with most conventional plumbing and fixtures.		

Table 4.1.5.1-d Water Conservation Measures and Impacts on Wastewater Flows, Bathing Devices and Systems.

Generic Type	Description	Development Stage[a]	Application Considerations	Water Use liters/min.	Water Use gal./min.
Air-Assisted Low-Flow Shower System	Specifically designed system uses compressed air to atomize water flow and provide shower.	2	Requires compressed air source. Power source required. Maintainance of air compressor. Power use = 0.01 KWH/use. May be impossible to retrofit. Shower location <50 feet from water heater.	1.9	0.5

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[a] 1 = Prototype developed and under evaluation.
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3 = Fully developed, limited use, not locally available, mail order purchase likely.
4 = Fully developed, limited use, locally available from plumbing supply houses or hardware stores.
5 = Fully developed, widespread use, locally available from plumbing supply houses or hardware stores.

Table 4.1.5.1-e Water Conservation Measures and Impacts on Wastewater Flows, Miscellaneous Devices.

Generic Type	Description	Development Stage[a]	Application Considerations	Total Flow Reduction lpcd	Total Flow Reduction gpcd	Total Flow Reduction %
Faucet Inserts	Device which inserts into faucet valve or supply line and restricts flow rate with a fixed or pressure compensating orifice. Varieties: Many.	4	Compatible with most plumbing. Installation simple.	3.8-7.6	1.0-2.0	3
Faucet Aerators	Devices attached to faucet outlet which entrain air into water flow. Varieties: Many.	5	Compatible with most plumbing. Installation simple. Periodic cleaning of aerator screens.	3.8-7.6	1.0-2.0	3
Reduced-Flow Faucet Fixtures	Similar to conventional unit, but restrict flow rate with a fixed or pressure compensating orifice. Varieties: Many.	4	Compatible with most plumbing. Installation identical to conventional.	3.8-7.6	1.0-2.0	3
Mixing Valves	Specifically designed valve units which allow flow and temperature to be set with a single control. Varieties: Many	5	Compatible with most plumbing. Installation identical to conventional.	3.8-7.6	1.0-2.0	3
Hot Water Pipe Insulation	Hot water piping is wrapped with insulation to reduce heat loss from hot water standing in pipe between uses. Varieties: Many.	4	May be difficult to retrofit.	3.8-7.6	1.0-2.0	3

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[a] 1 = Prototype developed and under evaluation.
2 = Development complete, commercial production initiated, not locally available.
3 = Fully developed, limited use, not locally available, mail order purchase likely.
4 = Fully developed, limited use, locally available from plumbing supply houses or hardware stores.
5 = Fully developed, widespread use, locally available from plumbing supply houses or hardware stores.

Table 4.1.5.1-f Water Conservation Measures and Impacts on Wastewater Flows, Recycle Options.

Description	Development Stage[a]	Application Considerations	Total Flow Reduction lpcd	Total Flow Reduction gpcd	Total Flow Reduction %
Recycle bath and laundry for toilet flushing.	2	Requires separate toilet supply and drain line. May be difficult to retrofit to multi-story building. Requires wastewater disposal system for toilet and kitchen sink wastes.	60.6	16.0	36
Recycle portion of total wastewater stream for toilet flushing.	3	Requires separate toilet supply line. May be difficult to retrofit to multi-story building. Requires disposal system for unused recycle water.	60.6	16.0	36
Recycle toilet wastewaters for flushing water carriage toilets.	4	Requires separate toilet plumbing network. Utilizes low-flush toilets. Requires system for nontoilet wastewaters. May be difficult to retrofit. Application restricted to high use on multi-unit installations.	60.6	16.0	36
Recycle total wastewater stream for all water uses	1-2	Requires major variance from state/local health codes for potable reuse. Difficult to retrofit.	170.6	45.0	100

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[a] 1 = Prototype developed and under evaluation.
2 = Development complete, commercial production initiated, not locally available.
3 = Fully developed, limited use, not locally available, mail order purchase likely.
4 = Fully developed, limited use, locally available from plumbing supply houses or hardware stores.
5 = Fully developed, widespread use, locally available from plumbing supply houses or hardware stores.

Based on the normal waste flow information presented in Table 4.1.5.1-b.

Source: USEPA. October 1980.

4.1.5.1 Continued

The per capita/day savings can be used to estimate the area's total daily savings. This savings is then subtracted from the existing total wastewater flow value to determine the potential reduced total wastewater flow value.

ALTERNATIVE DEVELOPMENT PROCEDURES WERE DESIGNED TO SYSTEMATICALLY ADDRESS PROBLEMS AND CONDITIONS SPECIFIC TO NORTH CAROLINA BARRIER ISLANDS

EPA Region IV has recognized the barrier islands as unique, discrete components of the coastal zone with problems and conditions specific to the area and warranting special attention and protection. Thus, the EIS procedures systematically identify and screen all feasible wastewater management system alternatives. The resulting strategy coordinates information on existing systems' performance, existing and/or potential pollution problems, physical conditions and constraints of the area, and local governments' institutional and financial capabilities. The procedures that make up the integrated development strategy were designed to delete unfeasible alternatives from detailed investigation without excluding viable alternatives from further evaluation.

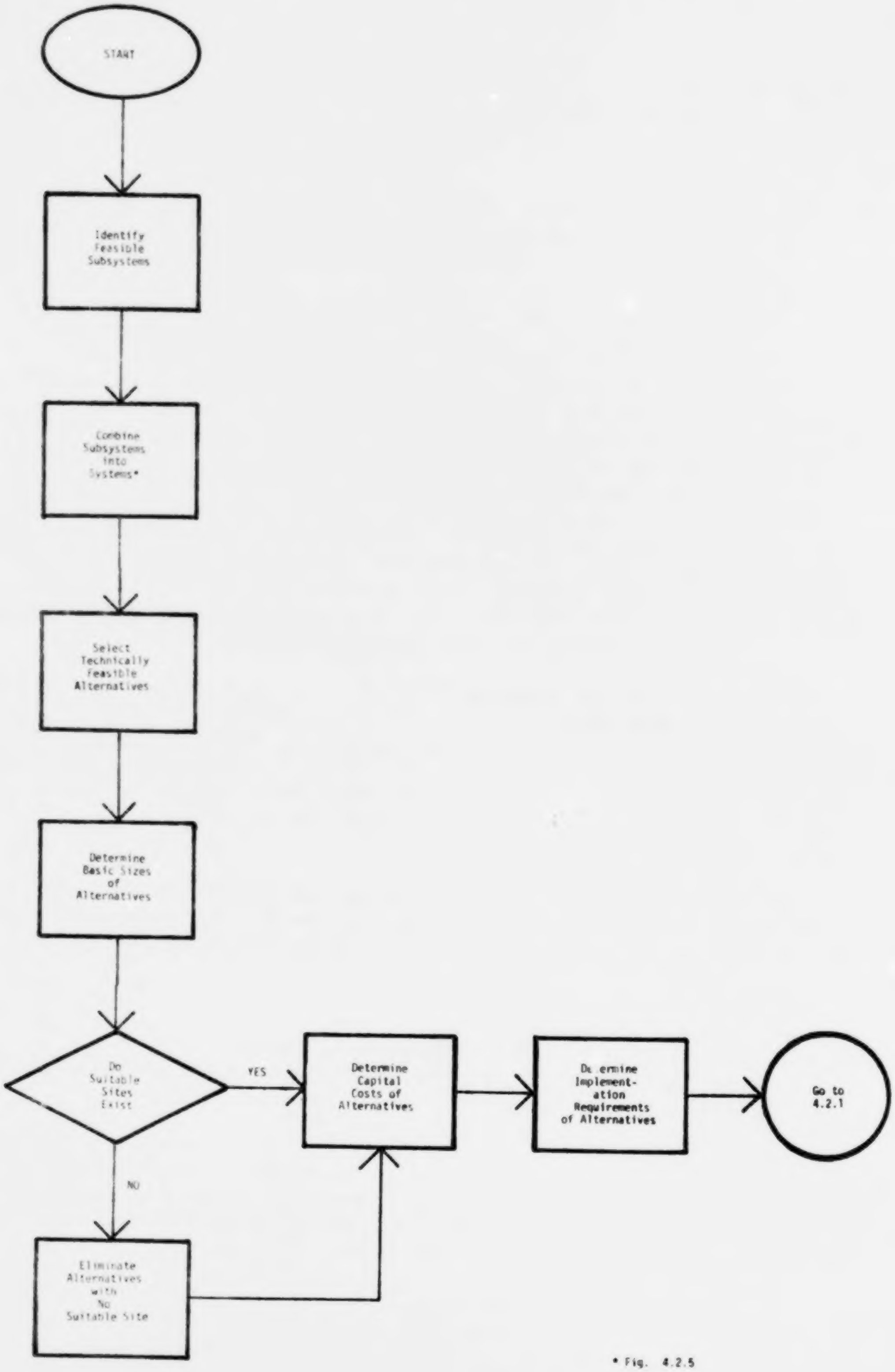
The development of principal alternatives for further evaluation based on cost-effectiveness potential involves the identification and screening of all technically feasible wastewater management system alternatives. The procedures established in this section make up an integrated strategy that systematically addresses the problems and conditions unique to North Carolina barrier islands. Figure 4.2 illustrates the procedures for the alternative development strategy.

The first step is the identification of potentially feasible subsystems. These subsystems address the various technical components of a wastewater management system and include the facilities for the following:

- Collection of the wastewater
- Treatment of the wastewater
- Disposal of the treated wastewater effluent
- Handling/disposal of the sludge and/or septage generated by the systems.

To facilitate the process, information on existing systems along with documentation of identified pollution problems is incorporated to determine the extent of pollution due to the inadequacy of existing systems. The identification of reasonable alternatives to existing systems is then performed based on general conditions in the area.

After this process, combining of subsystems into overall systems can be initiated. This step involves the development of the technical components previously identified into viable system alternatives based on the characteristics of the various technical components. To ensure that a complete list of feasible alternatives is identified for all possible development densities and patterns, consideration is given to the various degrees of


START
Identify Feasible Subsystems
Combine Subsystems into Systems*
Select Technically Feasible Alternatives
Determine Basic Sizes of Alternatives
Do Suitable Sites Exist
YES
Determine Capital Costs of Alternatives
Determine Implementation Requirements of Alternatives
Go to 4.2.1
NO
Eliminate Alternatives with No Suitable Site

* Fig. 4.2.5

Figure 4.2 Methodology for Developing Alternative Wastewater Management Systems

Source: Gannett Fleming Corddry and Carpenter, Inc., 1981.

system centralization. The overall system alternatives are therefore categorized into three types of systems: individual on-site systems, community systems and central/regional systems. These systems can then address all development on the barrier islands which is assumed to take one of the following forms:

- Scattered permanent and seasonal homes
- Cross-road clusters of year-round residents
- Concentrated developments of mostly seasonal homes and commercial facilities, often adjacent to shorelines.

These forms not only consider the rural nature of much of the islands but also the large seasonal population and growth of high-density residential and commercial development.

The categories of the treatment/disposal systems are also intended to facilitate the screening process which is the next step in the development of alternatives. This step results in the development of the principal technical alternatives. Screening of the feasible alternatives identified is to be based on system characteristics and requirements, specified site conditions and design factors, after which the system alternatives not eliminated will be analyzed according to their implementation requirements. From this point, the total system alternatives are to be subjected to cost-effectiveness analysis and evaluation as described in Section 4.3.

THE PROCEDURE FOR IDENTIFYING WASTEWATER TREATMENT/DISPOSAL TECHNOLOGIES INCORPORATES THE GENERAL PHYSICAL CONDITIONS OF THE BARRIER ISLANDS

Consideration was given only to those system alternatives compatible with physical conditions prevailing on the islands in terms of geology, topography, soils, climate, groundwater regime and surface water hydrology. To allow for various development densities, potentially feasible systems were categorized as individual on-site, community or central/regional systems.

In the identification of reasonable alternatives for wastewater management systems, only those system alternatives that would be compatible with the physical conditions of the study area were included.

- Geology dominated by unconsolidated sediments
- Topography generally consisting of beaches, dunes and flats
- Soils principally granular in structure, ranging from deep and excessively well-drained to shallow and poorly drained and subjected to flooding
- Moderate climate with fairly uniform temperature, precipitation, wind speed and relative humidity with intermittent occurrences of tropical storms, hurricanes and northeasters
- Groundwater regime consisting of a lighter freshwater lens floating atop the heavier salt water; water table depths are highly variable but generally tend to be very shallow due to seasonal high groundwater levels
- Primary surface waters are salt and brackish waters that are a mixture of saltwater from the ocean and fresh water from inland runoffs forming a complex hydrological system.

In order to allow for all possible development densities and patterns, the potentially feasible alternatives were categorized into three types of systems: individual on-site, community and central/regional. The following subsections provide a general description of each system type.

Individual Systems

These systems are aimed at the individual homeowner or small commercial establishment. Historically these systems have worked well on barrier islands. A variety of modifications to conventional on-site systems have been developed and proven technically feasible in areas when the performance of conventional systems is marginal. Mound and STEP systems offer significant advantages.

The most innovative option for on-lot wastewater treatment is the technology of separate handling of toilet wastes (blackwater) and other household wastewater (graywater). Even though this option, with all its variations, is included in the list as a reasonable alternative, it is a relatively unproven technology with not well defined advantages partly due to the fact that it requires dual treatment systems.

Existing on-lot systems on barrier islands have been cited as sources of pollution of nearby surface and groundwaters and of health hazards after rainfalls. Several field monitoring and sampling programs have found this to be true in specific sites, but studies have not yet established if it is an area-wide problem. Conversion of existing conventional, on-site disposal fields (soil absorption beds and trenches) to alternative on-site systems, in areas of unsuitable soils, resolve many of the problems stemming from excessively permeable sands and shallow soils with a high water table. In order to attain optimum operation of existing systems, a concerted effort must also be made to repair or upgrade septic tanks and possibly modify the soil absorption fields if little or no wastewater renovation is occurring within the soil medium. Also, in areas where well contamination is a threat to public health, renovation of on-site systems could be accompanied by improved water systems.

Community Systems

A community system serves small clusters, usually ten to several hundred residences. It involves centralized collection in conjunction with treatment/disposal alternatives that do not differ significantly from individual systems, although a few more options become feasible. Small community systems can provide a wastewater management solution in an area of failing individual systems and preclude the need for connection to a central/regional system, if one is available. Small community systems may also be used for new development at densities greater than those supported by individual on-site systems or in areas not suited for individual on-site systems due to poor soils or seasonally high water tables. For these small systems, the cost of collection, especially by force mains and conventional gravity sewers, is often prohibitive. Therefore, the alternatives identified for the collection system are a major factor of the whole system. With the larger flows from a collection system, flow equilization prior to treatment units, particularly package plants, should be utilized.

Central/Regional Systems

These systems have been the traditional approach to sewerage service and involve extensive collection systems leading to a centralized treatment facility. Although this type of system is costly in low density, rural areas, it has the advantage of providing a unified collection system and single treatment location. In some cases, the improved system operation due to centralization of maintenance responsibilities can lead to total cost savings over many segregated community and individual systems. The main consideration is that a sufficient, relatively contiguous development be available to make this approach financially viable. To minimize collection costs for a large-scale system, the innovative collection alternatives used for community systems can be incorporated in the collection/transport system whenever possible for these regional systems.

4.2.1 Continued

Sludge/Septage Handling and Disposal Systems

This has been considered an important factor in wastewater management system development for barrier islands and is a component of all alternative systems. Many techniques are suitable for both septage and sludge disposal and have limited application based mainly on constraints due to state regulations, land area availability, and volume of sludge and/or septage generated by the treatment components in the various system alternatives. All sludge/septage disposal alternatives are generally centrally managed and operated, regardless of the type of wastewater treatment/disposal system utilized.

Table 4.2.1 is a summary of the alternatives' technical components that were identified and include all the technical components that make up a wastewater management system. A detailed description of each alternative is provided in Appendix B, Details of Wastewater Management Options. Included in Appendix D, Wastewater Management System Selection Criteria, are lists of advantages, disadvantages, modifications and constraints for each alternative. Additionally, engineering design data for each of these systems is presented in Appendix C, Wastewater Treatment Alternatives Engineering Design Criteria.

Table 4.3.1 Summary of Wastewater Treatment/Disposal System Alternatives

System Type	Collection Options	Wastewater Treatment/Disposal Options	Sludge/Septage Treatment Options
Individual		1. Septic Tank/Conventional Soil Absorption Field 2. Septic Tank/Modified Conventional Soil Absorption Field 3. Septic Tank/Low Pressure Piping System 4. Septic Tank/Mound System 5. Septic Tank/Artificially Drained System (High Water table is lowered) 6. Septic Tank/Evapotranspiration (ET) Bed 7. Septic Tank/Evaporation Lagoon (E) 8. Septic Tank Polishing/Surface Discharge 9. Aerobic Treatment Units/Non-Surface Disposal (soil absorption field, mound system, ET bed, E lagoon) 10. Aerobic Treatment Units/Surface Discharge 11. Holding Tank for Temporary Storage of Wastewater and Later Transport (Usually via Tank Truck) to Central Disposal Site. 12. In-House Wastewater Treatment and Recycle (incl. Composting Toilets) 13. Wastewater Segregation and Reuse	1. Land Application of Sludge/Septage 2. Sludge Landfilling-Area Fill 3. Sludge Storage 4. Sludge Landfilling-Trenching 5. Sludge/Septage Lagoon 6. Co-Incineration 7. Composting Sludge/Septage 8. Septage Treatment/Disposal 9. Conventional Landfill
Community	1. Small Diameter Gravity Sewers 2. Vacuum Sewers 3. Pressure Sewer, STEP (Septic Tank Effluent Pump) 4. Pressure Sewer, GP (Grinder Pump) 5. Conventional Gravity Sewers	1. Community Soil Absorption Field 2. Community Septic Tank & Mound System 3. Community Evaporation and Evaporation/Infiltration Lagoons 4. Multiple-Compartment Septic Tank/Soil Absorption Field 5. Lagoon/Spray Irrigation (Slow Rate) System 6. Package Plant/Surface Water Discharge 7. Package Plant/Percolation Ponds 8. Package Plant/Rotary Distributor 9. Marsh-Pond/Surface Water Discharge 10. Oxidation Ditch/Surface Water Discharge	1. Land Application of Sludge/Septage 2. Sludge Landfilling-Area Fill 3. Sludge Storage 4. Sludge Landfilling-Trenching 5. Sludge/Septage Lagoon 6. Co-Incineration 7. Composting Sludge/Septage 8. Septage Treatment/Disposal 9. Conventional Landfill
Central/Regional*	1. Gravity Sewers 2. Force Mains	1. Lagoon/Spray Irrigation (Slow Rate) System 2. Physical/Biological Treatment Plant/Inland Surface Water Discharge 3. Physical/Biological Treatment Plant/Ocean Outfall	1. Land Application Sludge/Septage 2. Sludge Landfilling-Area Fill 3. Sludge Landfilling-Trenching 4. Sludge/Septage Lagoon 5. Co-Incineration 6. Composting 7. Conventional Sanitary Landfill

*Central/Regional Systems can also incorporate the collection alternatives proposed for the Community Systems for their collection/transport systems, when feasible.

Note: For direct discharge alternatives obtain effluent limits from the N.C. Department of Natural Resources and Community Development, Div. of Environmental Management.

Source: Gannett Fleming Corddry and Carpenter, Inc. 1981.

THE UNDERLYING ASSUMPTION IS THAT ON-SITE SOIL ABSORPTION SYSTEMS HAVE WIDESPREAD APPLICABILITY

The first part of the screening process of potentially feasible alternatives is screening based on technical feasibility. This procedure involves a systematic approach that incorporates the proposed system's operation characteristics, site requirements and design wastewater loadings.

The procedure for the technical feasibility screening of the identified alternatives is illustrated in Figure 4.2.2. This procedure involves a comprehensive process that incorporates many factors of the alternatives' capabilities and limitations. The underlying assumption is that the conventional individual septic tank/soil absorption system has widespread suitability, but under certain conditions the system would not function successfully. Therefore, the procedures identify a list of viable alternatives. This screening requires the establishment of criteria to be used in the determination of site suitability for subsurface soil absorption systems. Appendix D lists the site parameters that are considered through experience and research to be the criteria that determine a site's condition and limitations of suitability. Also, Section 4.2.2.1 describes the siting of on-site soil absorption fields for future development.

The first step in this procedure, illustrated by Figure 4.2.2, is to define the wastewater flow characteristics. This procedure was described in detail in Section 4.1.5 and enabled the potential alternatives to be sized for the screening analysis. The incorporation of water conservation measures is considered in the screening procedures on the assumption that if a user incorporates them, the land area requirements for soil absorption systems and the design flow capacity of treatment units will be significantly reduced. The North Carolina State Building Code requires that all new construction after April 1980 use 11.4 l/min (3.0 gal/min) showerheads and 13.3 l (3.5 gal) capacity toilet tanks.

Only non-water carriage toilets and wastewater recycle/reuse systems are identified as reasonable viable treatment/disposal system alternatives and addressed in Section 4.1.5.1. Other conservation methods are used only to reduce the wastewater flow generated and still require the installation of a treatment/disposal system to handle the wastewater flow.

The information resulting from determination of wastewater flow characteristics is used to initiate the next process, defining treatment requirements. This process utilizes the standards and regulations established by various government agencies at the federal, state and local levels. It also addresses the documentation obtained from the procedures of Section 4.1.3 that determine the source and extent of existing and potential water quality management problems.

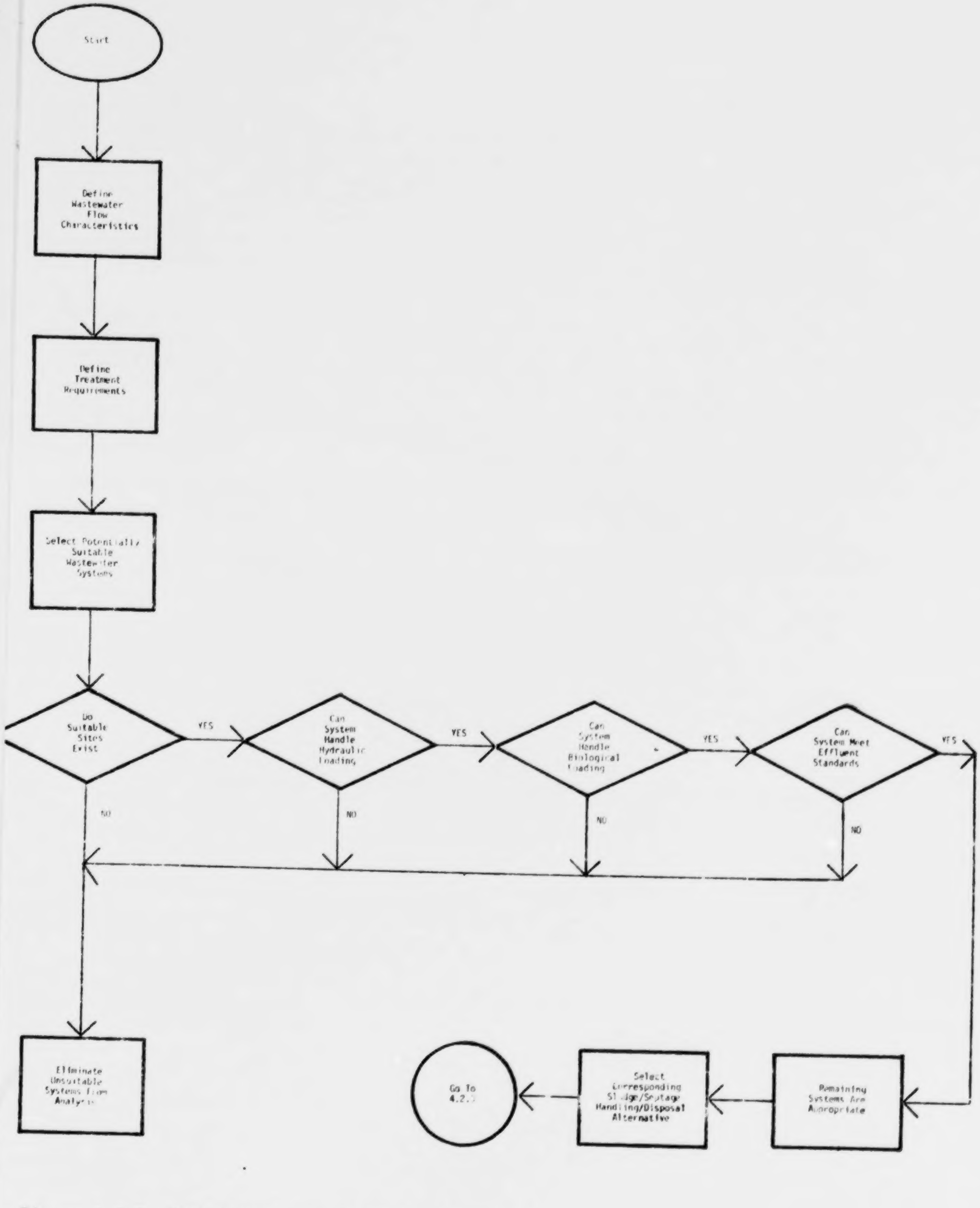

Start
Define Wastewater Flow Characteristics
Define Treatment Requirements
Select Potentially Suitable Wastewater Systems
Do Suitable Sites Exist
YES
NO
Can System Handle Hydraulic Loading
YES
NO
Can System Handle Biological Loading
YES
NO
Can System Meet Effluent Standards
YES
NO
Eliminate Unsuitable Systems From Analysis
Go To 4.2.3
Select Corresponding Sludge/Septage Handling/Disposal Alternative
Remaining Systems Are Appropriate

Figure 4.2.2 Methodology For Screening Technically Feasible Components of Wastewater Management Systems

Source. Gannett Fleming Corddry and Carpenter, Inc., 1981.

4.2.2 Continued

Once this process is complete, potentially suitable treatment systems can be selected for analysis. The screening process then considers the use o conventional individual septic tank/soil absorption systems. The analytical procedures will first review all potential individual systems, after which the review of community systems is to be undertaken. If no technically viable individual or community systems are found, then the potential central/regional systems will be reviewed to determine which ones are to be short-listed for future evaluation.

This selection of suitable treatment systems is basically made up of four decision points. The first is site suitability determinaton based on specific site characteristics and proposed system requirements. If a suitable site exists for the system alternative under consideration, then the analysis involved for the next two decision points can be completed. This analysis compares the hydraulic and biological loading characteristics of an alternative system to the need defined previously in the selection process.

The last decision process step analyzes the system alternative's potential treatment capabilities. It compares the efficiency and pollution reduction provided by a specific alternative to the required effluent standards established previously in this process. If the alternative system's performance is potentially acceptable, then the system is designated as appropriate and therefore listed as a principal alternative to be evaluated later for cost-effectiveness.

The last step in the screening process involves an analysis of the systems found to be appropriate to determine the final technical component of the wastewater management systems, sludge/septage disposal. The procedures used in developing technically feasible sludge/septage disposal techniques is based on land area availability and suitability and requirements of the selected wastewater treatment/disposal systems. These requirements include an assessment of both the volume and the type of sludge/septage generated.

AREAS OF EXISTING AND FUTURE DEVELOPMENT MUST BOTH BE ASSESSED

One of the more complex problems in assessing the wastewater management system requirements of an area or group of areas is that of determining what portion of that area's needs can be managed with on-site systems using soil absorption systems and what portion of the area's needs must be managed by use of some form of transport, treatment and disposal system.

This section delineates the steps that must be taken to determine what portion of an area's wastewater management requirements can be managed with on-site soil absorption systems and what portion of these needs should be managed with other forms of transport, treatment and disposal systems. This process is possibly best accomplished by preparing a base map of the area(s) to be studied. Generally, a soils map of the area will be the best type of map to use since areas with inappropriate soils for use with soil absorption systems can immediately be delineated. The base map should then have areas of high restrictive horizons represented on the map in a topographic fashion indicating areas with restrictive horizons:

- less than 12 inches from the surface
- 12-18 inches from the surface
- 19-24 inches from the surface
- 25-36 inches from the surface
- 37-48 inches from the surface
- greater than 48 inches from the surface.

Restrictive horizons are features which affect the treatment and assimilative performance of soil absorption systems and consist of high groundwater tables, impermeable subsoils or rock layers located near the surface. The investigator can then plot areas of development on this map and graphically depict areas that have common soil absorption system capabilities. Then by using technical guidelines such as the EPA's Design Manual: On-site Wastewater Treatment and Disposal Systems (October 1980), the investigator can determine the areas and densities that could be served by on-site soil absorption systems.

Initial consideration in Figure 4.2.2.1 is given to determining whether existing population presently served by soil abosrption systems is adequately served. If not, the next consideration is whether or not existing systems can be rehabilitated to provide adequate service. If this option is not available, then the number of persons and resulting flows requiring handling by other systems should be calculated and this figure reserved for later analyses.

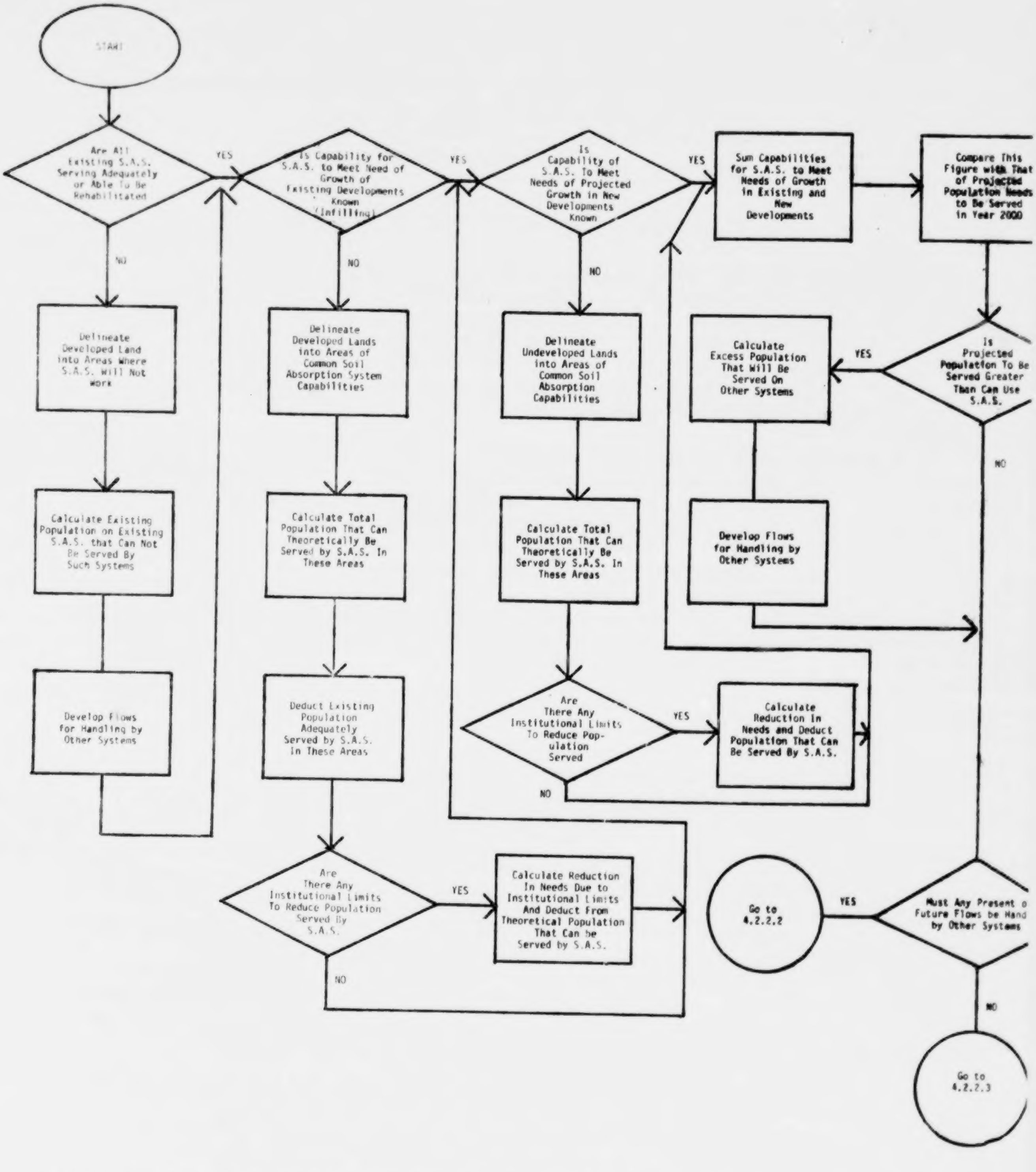

START
Are All Existing S.A.S. Serving Adequately or Able To Be Rehabilitated
YES
NO
Delineate Developed Land into Areas Where S.A.S. Will Not Work
Calculate Existing Population on Existing S.A.S. that Can Not Be Served By Such Systems
Develop Flows for Handling by Other Systems
Is Capability for S.A.S. to Meet Need of Growth of Existing Developments Known (Infilling)
YES
NO
Delineate Developed Lands into Areas of Common Soil Absorption System Capabilities
Calculate Total Population That Can Theoretically Be Served by S.A.S. In These Areas
Deduct Existing Population Adequately Served by S.A.S. In These Areas
Are There Any Institutional Limits To Reduce Population Served By S.A.S.
YES
NO
Calculate Reduction In Needs Due to Institutional Limits And Deduct From Theoretical Population That Can Be Served by S.A.S.
Is Capability of S.A.S. To Meet Needs of Projected Growth in New Developments Known
YES
NO
Delineate Undeveloped Lands into Areas of Common Soil Absorption Capabilities
Calculate Total Population That Can Theoretically Be Served by S.A.S. In These Areas
Are There Any Institutional Limits To Reduce Population Served
YES
NO
Calculate Reduction In Needs and Deduct Population That Can Be Served By S.A.S.
Sum Capabilities for S.A.S. to Meet Needs of Growth in Existing and New Developments
Compare This Figure with That of Projected Population Needs to Be Served in Year 2000
Is Projected Population To Be Served Greater Than Can Use S.A.S.
YES
NO
Calculate Excess Population That Will Be Served On Other Systems
Develop Flows for Handling by Other Systems
Must Any Present o Future Flows be Hand by Other Systems
YES
NO
Go to 4.2.2.2
Go to 4.2.2.3

Figure 4.2.2.1 Methodology for Determining Applicability of On-site Soil Absorption Systems (S.A.S.) to Given Area.

Source: Claude Terry & Associates, Inc., 1981

4.2.2.1 Continued

Future population may be accommodated either by infilling existing developed areas or by new development. Both of these options are explored in Figure 4.2.2.1.

The State of North Carolina has placed certain restrictions on the population that can be served in existing platted areas while having different restrictions on newly platted areas*. These institutional limits and the differences in them must be accounted for in determining the development patterns and the population that would result in existing developed areas and in projected developments (See Figure 4.2.2.1). This development pattern and population figure can then be compared with population projections for the year 2000, and it can readily be determined if there is adequate on-site soil absorption system capability to manage the projected population's wastewater management needs. If the projected population figure is greater than the capacity of on-site soil absorption systems, these additional future needs will have to be managed with other appropriate technologies or the projected development pattern and populations should be modified.

An in-depth discussion of the applicability and siting of on-site soil absorption system is included in Appendix C. Section 4.2.2.2 addresses options available to resolve additional projected wastewater management problems.

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*See Section 3.2.

4.0 DESCRIPTION OF ALTERNATIVE PROCEDURES DEVELOPED BY THE EIS

4.2 Procedures for Developing Alternative Wastewater Management Systems

4.2.2 Procedures for Selecting Technically Feasible Components of Wastewater Management Systems

4.2.2.2 Procedures for Developing a Series of Small Community and Central/Regional Alternatives When On-Site Systems Are Not Suitable

SMALL COMMUNITY SYSTEMS OFFER EXTENSIVE FLEXIBILITY IN TECHNOLOGY AND COSTS

Individual on-site systems are considered first. Thereafter, small community systems appear to offer local communities options to meet their wastewater collection, treatment and disposal needs. There is also flexibility to meet institutional, regulatory and financial constraints. A stepped methodology is presented to develop alternatives utilizing small community systems as well as regional systems.

Methodology

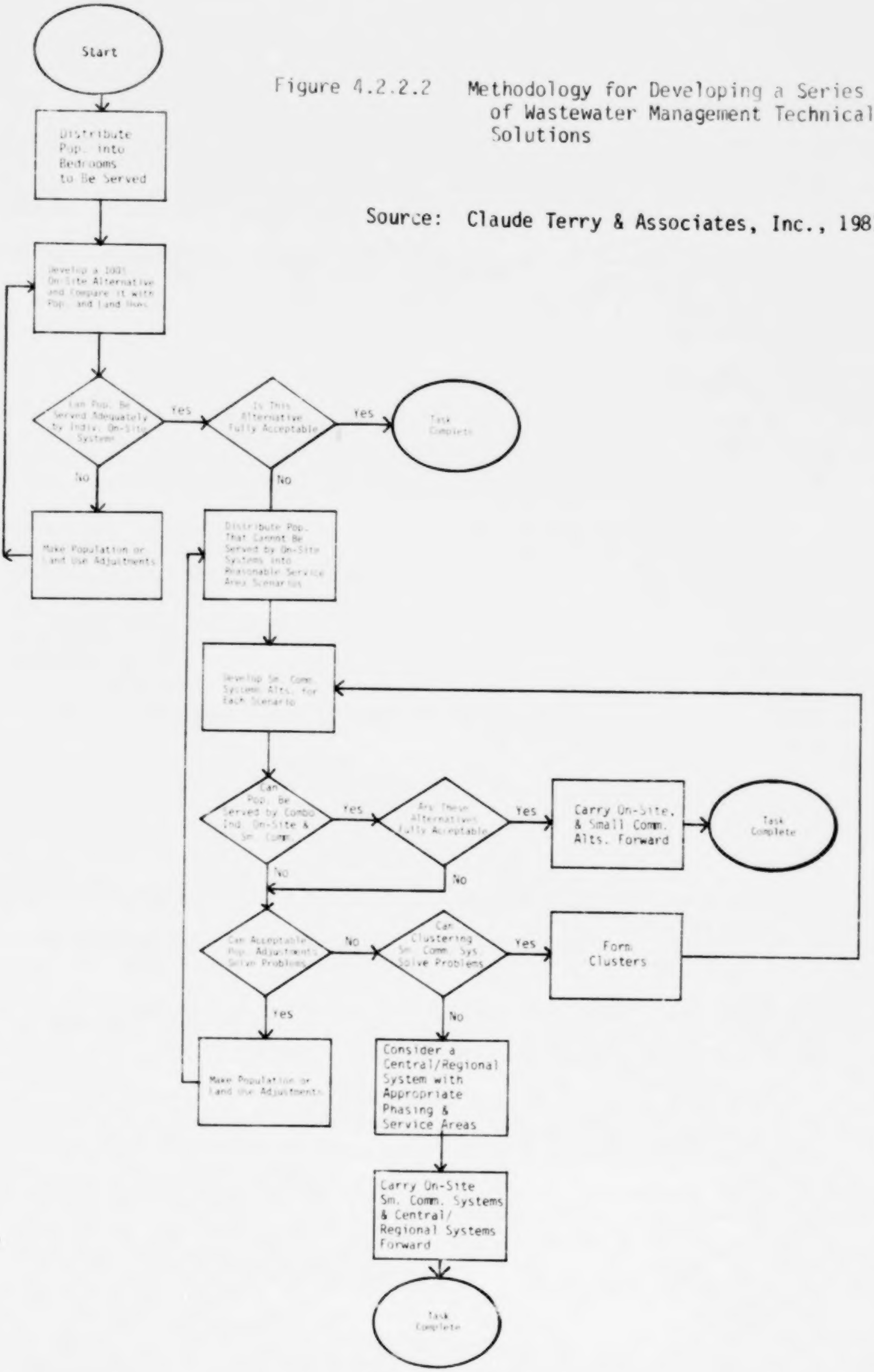
A straightforward method was shown in Figure 4.2.2.1 to determine if the needs of an island can be met by conventional and innovative on-site systems. Figure 4.2.2.2 is a methodology to develop other wastewater management technologies when it is determined that existing and future population cannot be fully served by on-site soil absorption systems.

Initially the projected population is distributed at the maximum bedrooms/acre allowed for those acres projected for future development. If insufficient land is available to serve the projected population using densities allowed by on-site systems, several alternatives exist. A first alternative is to consider whether the projected population numbers are realistic and desirable. If not, population projections can be revised downward, and the new figures can be checked to see if they now may be accommodated by on-site systems. If the new projections allow the population to be served, ascertain if the projection and resulting distribution are reasonable considering existing platting, zoning and known development interests. (Include environmental, socioeconomic and financial impacts in this determination of reasonableness.) If this adjustment is satisfactory, the need to publicly provide for off-site treatment has been removed, and no further alternatives development is necessary.

If the projected population adjustment and on-site systems are not fully acceptable, a minimum of two small community system alternatives should be developed. One alternative utilizing on-site systems to the maximum and small community systems to solve existing water quality problems should be developed. A second alternative utilizing on-site systems and small community systems for solving both existing water quality problems and accommodating future high density development should also be developed. These alternatives should be carried into more detailed development and evaluation tasks along with the previously developed on-site alternatives.

Figure 4.2.2.2 Methodology for Developing a Series of Wastewater Management Technical Solutions

Source: Claude Terry & Associates, Inc., 1981


Start
Distribute Pop. into Bedrooms to Be Served
Develop a 100% On-Site Alternative and Compare it with Pop. and Land Uses
Can Pop. Be Served Adequately by Indiv. On-Site Systems
Yes
No
Is This Alternative Fully Acceptable
Yes
No
Task Complete
Make Population or Land Use Adjustments
Distribute Pop. That Cannot Be Served by On-Site Systems into Reasonable Service Area Scenarios
Develop Sm. Comm. Systems Alts. for Each Scenario
Can Pop. Be Served by Combo Ind. On-Site & Sm. Comm.
Yes
No
Are These Alternatives Fully Acceptable
Yes
No
Carry On-Site, & Small Comm. Alts. Forward
Task Complete
Can Acceptable Pop. Adjustments Solve Problems
No
Yes
Can Clustering Sm. Comm. Sys. Solve Problems
Yes
No
Form Clusters
Make Population or Land Use Adjustments
Consider a Central/Regional System with Appropriate Phasing & Service Areas
Carry On-Site Sm. Comm. Systems & Central/Regional Systems Forward
Task Complete

4.2.2.2 Continued

If the small community systems alternatives are not fully acceptable, consideration should be given to adjusting projected populations, and/or grouping of the small systems. If these developed alterations are not fully acceptable, consideration should then be given to central/regional systems.

The major factors in developing central/regional systems are alternative phasing of facilities and alternative groupings of major service areas. Intergovernmental agreements to accomplish economies of scale should be considered.

Design Considerations

Several major considerations should be taken into account in developing small community systems alternatives. Initially, the available technologies for collection, treatment and disposal must be examined and evaluated. A list of the system elements commonly used appears in Appendices B-D.

Consideration should be given to the impacts of the various discharge modes. Discharge to surface water bodies is frequently precluded on barrier islands, both because of the lack of suitable receiving streams and because of the potential negative environmental impacts of such discharges. State law allows no discharges to SA waters. Discharges may be permitted to SC waters where adequate assimilative capacity exists. Surface discharges to estuaries are similarly regarded, due to potential impacts on shellfish and other resources. Ocean outfalls are typically not cost effective for disposing small volumes of effluent and may have undesirable impacts on beach-side communities.

The typical discharge modes on barrier islands involve surface or subsurface disposal of effluent on the soil. Several factors regarding wastewater disposal into groundwater deserve consideration. These factors include:

-Potential for human recreational body contact with bacteria and viruses from wastewater
-Bacterial and nitrate contamination of drinking water supplies
-Overenrichment of the near surface waters with nutrients.

Typically, such negative impacts can be avoided by incorporating proper elements in system design. Design criteria which can eliminate or significantly minimize the above mentioned effects include:

-Spatial separation of disposal areas from surface waters
-Disinfection systems to alleviate potential for bacterial contamination
-Spatial separation of wastewater discharges from potable water supply wells
-Consideration of depth to water table and use of mounds or other appropriate on-site technologies
-Consideration of the potential uses for the groundwater in the area of discharge. If no future use for potable water supply is planned, different loading considerations may be applicable.

4.2.2.2 Continued

After analysis of the above and other applicable design requirements, several potentially suitable on-site, small community and regional treatment systems and land areas suitable for ultimate disposal are to be developed for more detailed evaluation. Several reasonable combinations of system elements may be structured which meet the volume and load requirements within the constraints of hydrology, soils, depth to water table, topography and public health considerations. These systems should be examined for consistency with statutory and socioeconomic requirements (i.e., are the system components legal in North Carolina, what impact does the system have on neighboring land uses, etc.). The developed feasible systems then receive further consideration in subsequent tasks. Technically and institutionally acceptable alternatives should be evaluated for cost effectiveness at the volumes and loads to be handled.

Determination of the small community systems appropriate for a given community is best done with input from local sanitarians, hydrologists or similarly trained persons with local on-site experience. Each barrier island area is to some extent unique in wastewater treatment needs, soil quality and quantity available for use in treatment and disposal, financial capability to fund part or all of the needed facility, and social and political structure. While the needs may differ, many examples now exist nationally of small communities adapting various technologies to conform to their specific needs.

At the conclusion of the technical development of alternatives, several options are to be developed further (in subsequent tasks) and then considered in the detailed evaluation tasks. An alternative employing on-site systems with small community systems used to solve existing water quality problems should always be developed and carried through subsequent tasks. If this system is fully acceptable, no further alternative development is necessary. If not acceptable, an alternative comprised of on-site systems and small community systems to handle existing water quality problems and future high density areas is developed and carried through the remaining development and evaluation tasks. If these alternatives are not fully acceptable, various central/regional alternatives should also be developed and carried through the detailed development and evaluation tasks.

Differentiating between needs for the existing situation and needs relating to future growth is quite important, since the law and EPA eligibility requirements primarily relate to solving existing pollution problems. For example, if on-site and/or small community systems would solve existing problems but a regional sewer system was desired due to future growth, the more extensive and expensive facilities might not be fundable on the State priority list. These questions must also be very seriously considered at the local level in terms of whether communities wish to undertake the large financial commitments related to possible, but uncertain, future growth. This is especially important since Section 4.1.2, Population Projection Methodology, can convert a relatively small numerical increase in permanent population into thousands of seasonal, overnight, and day visitors which could very possibly not occur due to the factors listed in that section and elsewhere. Staging of different types of facilities should be evaluated and shown. These questions should receive a very rigorous review at the local level as well as in facility plan review.

4.0 DESCRIPTION OF ALTERNATIVE PROCEDURES DEVELOPED BY THE EIS

4.2 Procedures for Developing Alternative Wastewater Management Systems

4.2.2 Procedures for Selecting Technically Feasible Components of Wastewater Management Systems

4.2.2.3 Procedures for Determining the Hydrodynamic Response to On-Site Disposal of Wastewater

GROUNDWATER RECHARGE MAY CAUSE THE WATER TABLE TO RISE AND SATURATE DRAIN FIELDS

An analytical model is developed which estimates changes in the position of the water table of an island when wastewater is applied in a constant manner. Precipitation, evapotranspiration, aquifer conductivity and island width are needed to estimate the changes. The analytical procedure applies only to unconfined coastal aquifers where both fresh groundwater and saline groundwater are static. Individual storm events and variations in groundwater storage do not significantly affect results.

When determining the applicability of on-island disposal systems to a given area, it is important to consider the response of the water table aquifer to disposal of wastewater. Wastewater disposal on barrier islands should be considered a net addition to total groundwater recharge if water is initially obtained from mainland sources. This net addition could result in physical contact between the water table and the bottom of drain field trenches or even surfacing of effluent. These groundwater-related problems can be identified by following a procedure illustrated in Figure 4.2.2.3-a.

Fetter (1971) developed a procedure, based on the Ghyben-Herzberg principle (Fetter 1980), which allows estimation of changes in the water table hydrograph of a given cross-section of island. The application of Fetter's procedure applies to unconfined coastal aquifers where both fresh groundwater and saline groundwater are assumed to be static. This assumption does not introduce significant errors except in close proximity to the shoreline (see Figure II.11). At the shore edge, depth to the interface will be at a greater depth, and the elevation of the groundwater table above mean sea level will be slightly greater. For an island with groundwater flow only perpendicular to the shore line, the simplified equation takes the form

$$h^2 = \frac{w(a^2 - (a - x)^2)}{k} \quad (41)$$

h = water table elevation above mean sea level (ft)
w = average aquifer recharge (ft/day)
2a = island width (ft)
x = distance from the shoreline (ft)
k = hydraulic conductivity of the water table aquifer (ft/day)

Figure 4.2.2.3-b is a graphic representation of h, a and x. Aquifer recharge and hydraulic conductivity must be determined from published information or field studies. If more than one aquifer exists above the fresh-

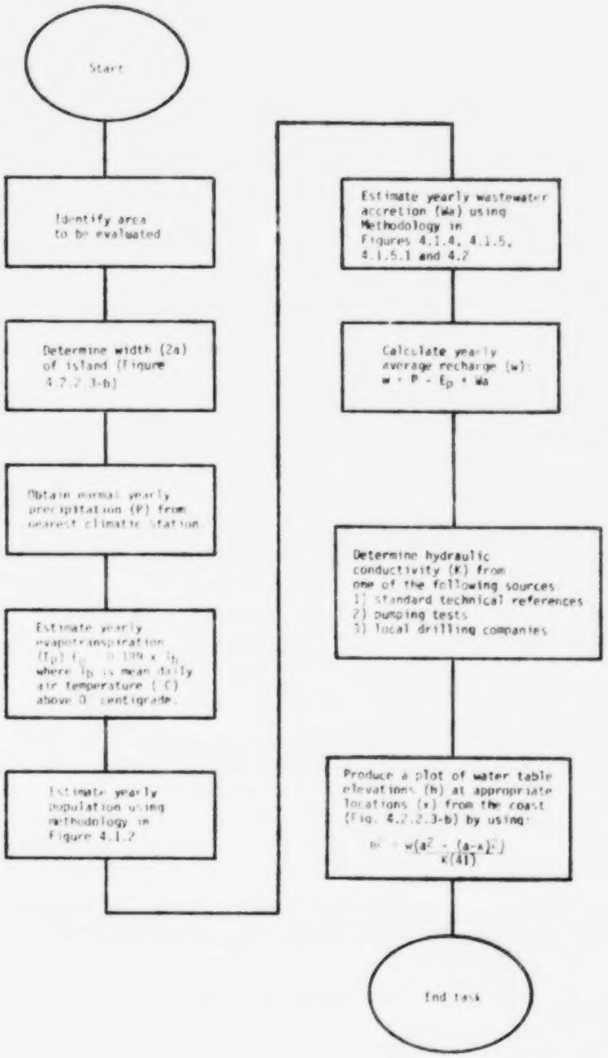
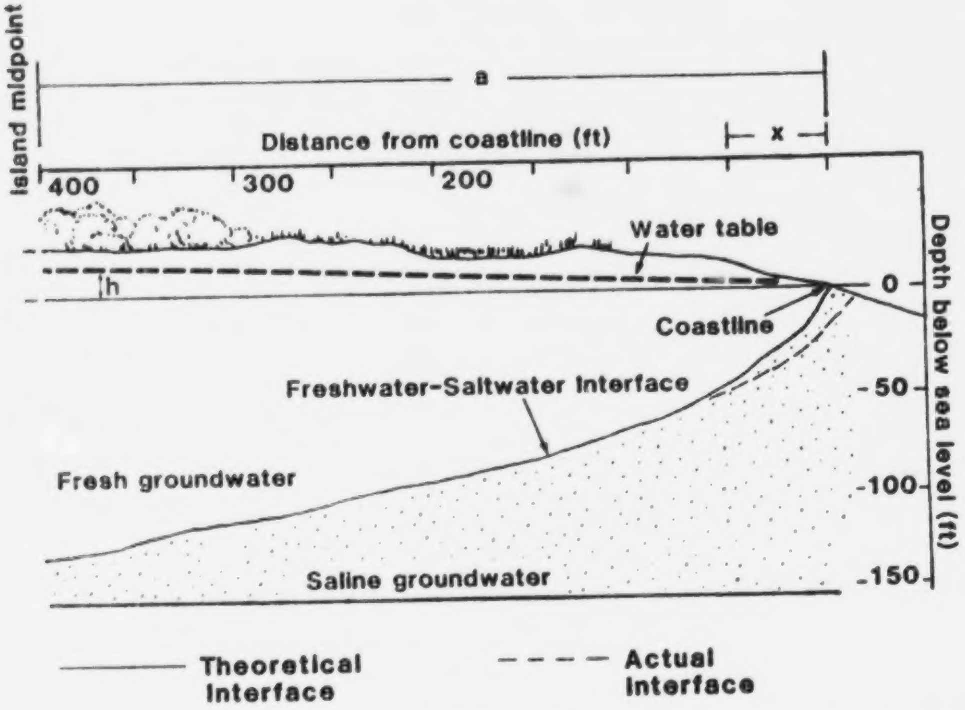

Start
Identify area to be evaluated
Determine width (2a) of island (Figure 4.2.2.3-b)
Obtain normal yearly precipitation (P) from nearest climatic station
Estimate yearly evapotranspiration (E_p) E_p = 0.189 x T_b where T_b is mean daily air temperature (°C) above 0° centigrade.
Estimate yearly population using methodology in Figure 4.1.2
Estimate yearly wastewater accretion (Wa) using Methodology in Figures 4.1.4, 4.1.5, 4.1.5.1 and 4.2
Calculate yearly average recharge (w): $w = P - E_p + Wa$
Determine hydraulic conductivity (K) from one of the following sources
1) standard technical references
2) pumping tests
3) local drilling companies
Produce a plot of water table elevations (h) at appropriate locations (x) from the coast (Fig. 4.2.2.3-b) by using:
$h^2 = \frac{w(a^2 - (a-x)^2)}{K(41)}$
End task

Figure 4.2.2.3-a. Methodology for Determining Water Table Elevation above Mean Sea Level for an Infinite-Strip Island

Source: Claude Terry & Associates, Inc. 1982.



Island midpoint
a
x
Distance from coastline (ft)
400
300
200
Water table
h
0
Coastline
Depth below sea level (ft)
Freshwater-Saltwater Interface
-50
Fresh groundwater
-100
Saline groundwater
-150
Theoretical Interface
Actual Interface

Figure 4.2.2.3-b Identification of Water Table Elevation (h), Island width (2a) and Distance from Coastline (x) Used in the Prediction Equation

Source: Fetter, C. W. Applied Hydrogeology. 1980

4.2.2.3 Continued

water-saltwater interface, k will equal the average hydraulic conductivity of existing aquifers. The assumptions of the equation are listed below:

- The freshwater-saltwater interface is very narrow.
- Hydraulic conductivity is constant across the island width.
- Groundwater flow is horizonal and only occurs perpendicular to the shore line.
- Wastewater loading is constant over time and space.
- Rainfall is at a constant rate over time and uniform over the island.
- Tidal influences near the coast are insignificant.

At the coastline, tidal influences may be significant. Septic tank soil absorption systems, however, are not usually built within 40 feet of the coastline. It is within this distance where tidal influences are most apparent; the influence is insignificant 50 feet and further from the coastline.

The influence of temporal variations in precipitation, wastewater disposal and groundwater storage is also not significant; mean daily recharge gives a close estimate of the water table elevation. A four-inch rainfall occurring in one day causes a long term increase in the water table elevation above mean sea level of one third of one inch (based on a porosity of 0.33). One example of the short term reaction due to a four inch storm event is shown in Appendix D, Table D.3. The water table (at any point where aquifer thickness = 200 ft) moves essentially back to pre-storm equilibrium in four days; 76 percent of the increase in storage is lost after one day. The additional recharge to the water table aquifer resulting from a four-inch rainfall stays in storage for at least several months. However, this carryover effect in storage is insignificant because only about 1/40 of the additional storage adds to the total height of the water table. Appendix D discusses these responses in greater detail.

Spatial variations in hydraulic conductivity can influence the results obtained when using the procedure described in this section. A 100 percent increase in hydraulic conductivity will result in a 30 percent decrease in water table elevation. Field studies would be appropriate where groundwater levels are close to the surface and no actual values for hydraulic conductivity are available.

Actual mounding of the water table and subsequent surfacing of effluent may occur where several septic systems are close together. Where mounding is likely, more detailed studies should be incorporated. The North Carolina Department of Natural Resources and Community Development, Office of Water Resources is presently refining a method, based on well drawdown, that estimates effluent mounding around rotary distributors (Shiver 1983). Fetter (1972) also developed a numerical solution that describes the hydrodynamic response of the water table to wastewater disposal on barrier islands. The DNRCD solution differs from Fetter's equation because the amount of recharge can be varied spatially across the island to reflect the distribution of wastewater recharge and mounding usually concomitant with densely placed septic tank systems.

4.2.2.3 Continued

(a) Aquifer Recharge

Recharge of the water table aquifer on barrier islands is mostly by rainfall; direct runoff is usually insignificant. Thus, recharge can be computed using the following balance equation:

Recharge = Precipitation - Evapotranspiration + Wastewater

Monthly and yearly values of normal precipitation for the barrier island region can be obtained from local weather stations. Techniques used to measure evapotranspiration are based on four general approaches: water budgeting, energy budgeting, vapor flow and empirical methods. The most common approach used to estimate evapotranspiration is through empirical models. Yearly evapotranspiration (Ep) can be computed using the following equation:

$$Ep = 0.189 \times T_b$$

T_b = mean daily air temperature (°C) above 0° Centigrade.

Wastewater flows are based on population estimates. Average monthly flow can be determined using the methodology presented in Figures 4.1.4, 4.1.5, 4.1.5.1 and 4.2.

(b) Hydraulic Conductivity

The hydraulic characteristic of the aquifer materials is expressed as the conductivity, a measure of the rate at which the aquifer can transmit a fluid. The hydraulic conductivity of an aquifer is usually determined from aquifer tests made on wells that penetrate the aquifer. Prickett (1965) presented a graphic method for the solution of hydraulic conductivity from aquifer tests in an unconfined aquifer. These tests indicate that most barrier islands have hydraulic conductivities that range from 25 ft/day to 200 ft/day; 50 ft/day would be a conservative value in water table calculations. Information regarding actual hydraulic conductivities might be obtained from local drilling companies or from standard reference sources.

(c) Model Results

Figure 4.2.2.3-c depicts three hydrogeological situations that can be predetermined by using the procedure outlined in this section. Point A on the figure represents a location where effluent might accumulate above ground. Point B represents a location that would only be suitable for construction of a septic system under existing occupancy because the predicted elevation of the water table under maximum occupancy intersects the lower boundary of the drainfield trench. Point C represents an area where groundwater seepage might occur under maximum occupancy. If a septic system is constructed adjacent to and above point C, effluent from the system might seep from the outflow face. Appendix D contains a hypothetical case study where detailed calculations have been made and conclusions drawn based on the position of the water table under existing and maximum occupancy.

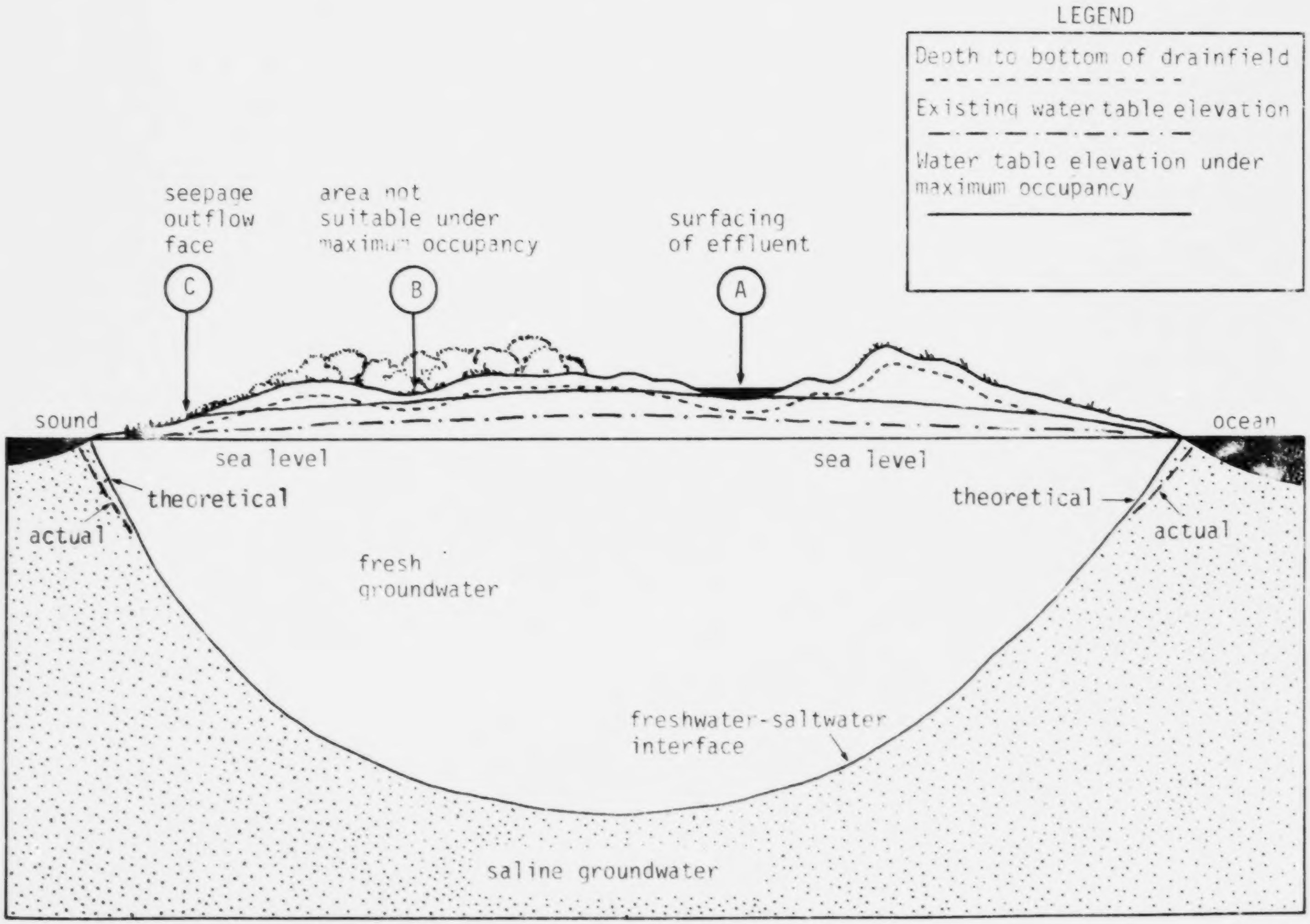

LEGEND
Depth to bottom of drainfield
Existing water table elevation
Water table elevation under maximum occupancy
seepage outflow face
C
area not suitable under maximum occupancy
B
surfacing of effluent
A
sound
ocean
sea level
sea level
theoretical
actual
theoretical
actual
fresh groundwater
freshwater-saltwater interface
saline groundwater

Figure 4.2.2.3-c Possible Hydrogeological Situations That Can Be Identified

Source: Claude Terry & Associates, Inc., 1982

4.2.2.3 Continued

The analytical solution presented in this section describes the hydrodynamic response of the water table to land disposal of wastewater in an idealized representation of actual aquifer configurations. In actuality, aquifers are not homogeneous nor is the permeability of the unit the same in all directions. Existing aquifers on barrier islands are created by complex geologic processes that in certain cases may have led to irregular stratigraphy of confined and unconfined aquifers. The prediction that can be carried out with the expression presented in this section is a best estimate; this estimate approaches more closely the actual hydrogeological environment as the actual conditions approach the idealized configuration.

COLLECTION COSTS ARE OFTEN A MAJOR COMPONENT

Cost estimates for collection systems should be done in stages. Alternative or innovative collection systems should be considered when they can be shown to be cost-effective. The size and cost of each component must be developed. Unit cost information should be developed from manufacturer's data where possible. Construction costs can be developed from EPA information or local contractors.

Figure 4.2.2.4 shows that the first step in developing costs of wastewater collection systems is to determine the exact area in need or designated to be sewered. This area should be delineated on topographic maps that show the total number of lots and existing development. Collection line layouts and wastewater flow estimates can be developed from this information.

Gravity collection lines are the most commonly used conveyance system due to their dependability and relatively low operation and maintenance costs. However, some circumstances such as high groundwater tables make gravity collection less desirable than some other alternatives. In these situations, alternative means of wastewater collection are appropriate. Normally, these systems are either vacuum or pressure sewers which can be more cost effective because they do not depend on pipe slope to move the wastewater. It is possible for a conveyance system to be comprised of several types of collection facilities.

When developing costs for a collection system in a particular area, the alignment of gravity sewers should be determined first to take maximum advantage of the natural slope. After this has been completed, subareas that may benefit from an alternative collection system can be identified. Developing costs for conventional and alternative collection systems requires different techniques and should be calculated separately.

Conventional Gravity Sewers Costs Estimating Procedures

Sewer length can be developed by measuring the sewer alignments or by utilizing information such as that shown in Table 4.2.2.4-a to estimate the needed length. The information is based on population density which should be available or readily obtainable.

Sizing of collector sewers is based upon that portion of expected discharge flow to be discharged to sewers. The size of the collector line is based on the amount of water to be carried and the slope of the line. Table 4.2.2.4-b lists the discharge range for common pipe diameters. This information can be used for planning purposes when no slope information is available.

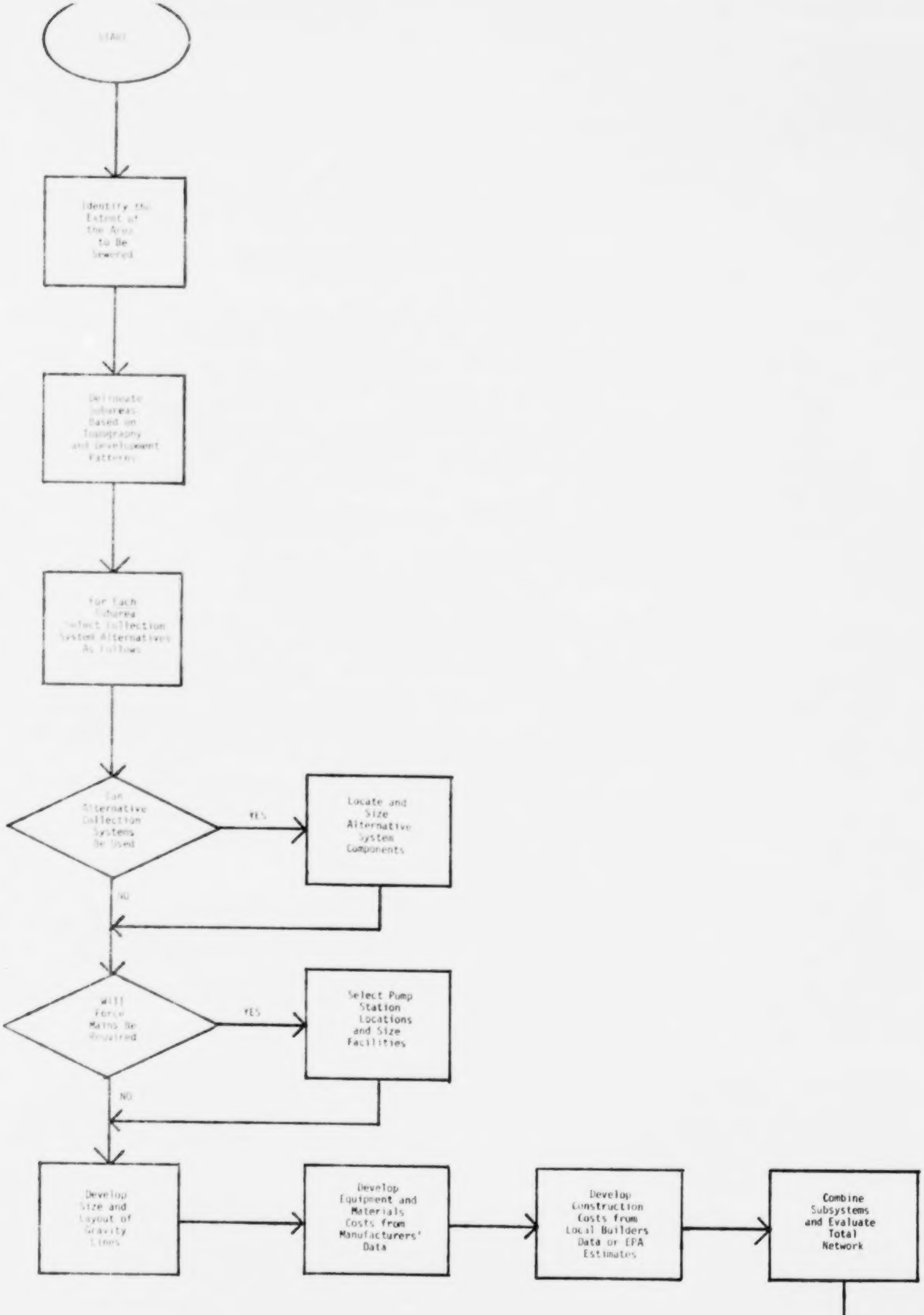

START
Identify the Extent of the Area to Be Sewered
Delineate Subareas Based on Topography and Development Patterns
For Each Subarea Select Collection System Alternatives As Follows
Can Alternative Collection Systems Be Used
YES
NO
Locate and Size Alternative System Components
Will Force Mains Be Required
YES
NO
Select Pump Station Locations and Size Facilities
Develop Size and Layout of Gravity Lines
Develop Equipment and Materials Costs from Manufacturers' Data
Develop Construction Costs from Local Builders Data or EPA Estimates
Combine Subsystems and Evaluate Total Network
Go to 4.2.2.5

Figure 4.2.2.4. Methodology for Estimating Collection System Costs.

Source: Gannett Fleming Corddry and Carpenter, Inc., 1981.

4.2.2.4 Continued

When pump stations are necessary, various methods can be used to develop costs without specific head requirements. In such instances, data for neighboring community systems may provide useful information. In cases where no information is available, pump stations can be sized for estimating system costs only to handle the maximum flow for the calculated pipe diameter. Pump station construction costs can be developed from various publications such as EPA's Construction Cost for Municipal Wastewater Conveyance Systems: 1973-1977.

Alternative Sewers Cost Estimating Procedures

Development of costs for alternative systems generally follows the same procedures as for conventional systems. The primary difference is the type of components. For example, where there are significant number of existing septic tanks, effluent wastewater pumps should be evaluated.

After the sewer line has been delineated, the required length can be determined using the information in Table 4.2.2.4-a or by measuring the delineated sewer lines (preferred method). Pipe sizes will be dependent upon the number of people being served by each line. This information can be determined from publications such as the Design Handbook for Low Pressure Sewer Systems by Environment One Corporation.

The number of pumps required by the alternative system will depend on factors such as population density and system configuration. Once the number of pumps has been determined, the costs can be calculated using unit costs from manufacturers.

Various EPA publications are available to help determine cost for collection systems. Other publications are available from manufacturers of pumps, pipes and tanks. As much information as possible should be collected before cost estimates are attempted. The better and the more detailed the information, the better the chances for good cost estimates and correct alternative selection.

Table 4.2.2.4-a Separate Sanitary Sewer Collector Per Capita Length vs. Population Density.

Point Estimates

Population Density (people/acre)	Per Capita Sanitary Collector Length (m)	(ft.)
0.75	9.3	30.5
1.50	8.2	27.0
2.50	7.4	24.1
3.00	7.0	22.9
5.00	5.9	19.5
10.00	4.3	14.1
15.00	3.2	10.5
20.00	2.3	7.7
30.00	1.1	3.6

Estimating Equation

$Y = 5.2 - 22.05\ X\ 0.2265$

$R = -0.977$

$N = 19$ Population density strata

Where X = Per capita sanitary collector length (m or ft)

Y = Population density (people/acre)

Valid range = 0.75 - 30 people/acre

Source: USEPA. 1981.

Table 4.2.2.4-b Sizing of Gravity Collector and Interceptor Sewers.

Design Discharge Range		Pipe Diameter	
(m^3d)	(mgd)	(cm)	(in)
303.2 or less	0.08 or less	15.24	6.0
303.2-664.3	0.08 - 0.17	21.32	8.0
664.3-1099.1	0.17 - 0.29	24.50	10.0
1099.1-1781.3	0.29 - 0.47	30.48	12.0
1781.3-3107.8	0.47 - 0.82	38.10	15.0
3107.8-4927.0	0.82 - 1.3	45.72	18.0
4927.0-7201.0	1.3 - 1.9	53.34	21.0
7201.0-10,233.0	1.9 - 2.7	60.96	24.0
10,233.0-14,402.0	2.7 - 3.8	68.58	27.0
14,402.0-18,571.0	3.8 - 4.9	76.20	30.0
18,571.0-30,320.0	4.9 - 8.0	91.44	36.0
30,320.0-44,722.0	8.0 - 11.8	106.68	42.0
44,722.0-64,430.0	11.8 - 17.0	121.92	48.0
64,430.0-85,275.0	17.0 - 22.5	137.16	54.0
85,275.0-111,805.0	22.5 - 29.5	152.40	60.0
111,805.0-142,125.0	29.5 - 37.5	167.64	66.0
142,125.0-181,920.0	37.5 - 48.0	182.88	72.0

Source: USEPA. January 1978.

4.2.2.5 Procedures for Identifying Additional Costs Incurred on Barrier Islands

MOST STRUCTURES BUILT ON THE BARRIER ISLANDS REQUIRE SPECIAL DESIGNS THAT INCREASE CONSTRUCTION AND OPERATION AND MAINTENANCE COSTS

In addition to the normal construction and operation and maintenance costs associated with wastewater management facilities, the effects that weather, sea, sand and poor load bearing soils have on the construction and operation of facilities in the barrier islands must be accounted for in cost estimates.

Since the soil characteristics in many areas are not suitable for the foundations of treatment facility structures, the additional cost of pilings or other special foundations has to be considered. Additionally, structures have to be built to withstand the effects of weathering including high winds, sea spray corrosion and sand abrasion. These parameters affect both the initial construction costs of any wastewater management system and the long term operation and maintenance costs of the system.

The problems associated with foundations and constructing facilities to withstand the forces of the winds encountered on the barrier islands are the primary additional costs associated with initial construction costs. The investigator must factor these costs into all cost estimates for new facilities prior to calculating life-cycle costs for the structure. Additionally, the investigator should determine if increased initial costs for heavy duty coatings, more ruggedly constructed treatment equipment or the use of stainless steel in place of other less corrosive and erosive metals can be justified over the life of the facility due to decreased operation and maintenance costs of more weather resistant facilities.

Sand and salt spray have a detrimental effect on the serviceability of structures and equipment. Facilities constructed on the barrier islands must be recoated or painted more often, bearings have to be repacked more often and wear of all moving parts is increased due to the sand and corrosion problems. Quantifying the additional costs associated with these problems necessitates studying manufacturers' coatings data to determine the expected lives of their coatings, determining the effects that the weather and sand will have on the designed bearing life of critical equipment and evaluating the effects that the corrosive atmosphere will have on electrical equipment. In most instances, these are engineering questions that will have to be answered by professionals in their respective fields. The investigator should be aware of these areas of additional cost and add them to the costs obtained from normal 201 cost calculation procedures for any facility proposed for the barrier islands.

Figure 4.2.2.5 is a diagram summarizing the procedures required for developing construction and O & M costs of wastewater management facilities.

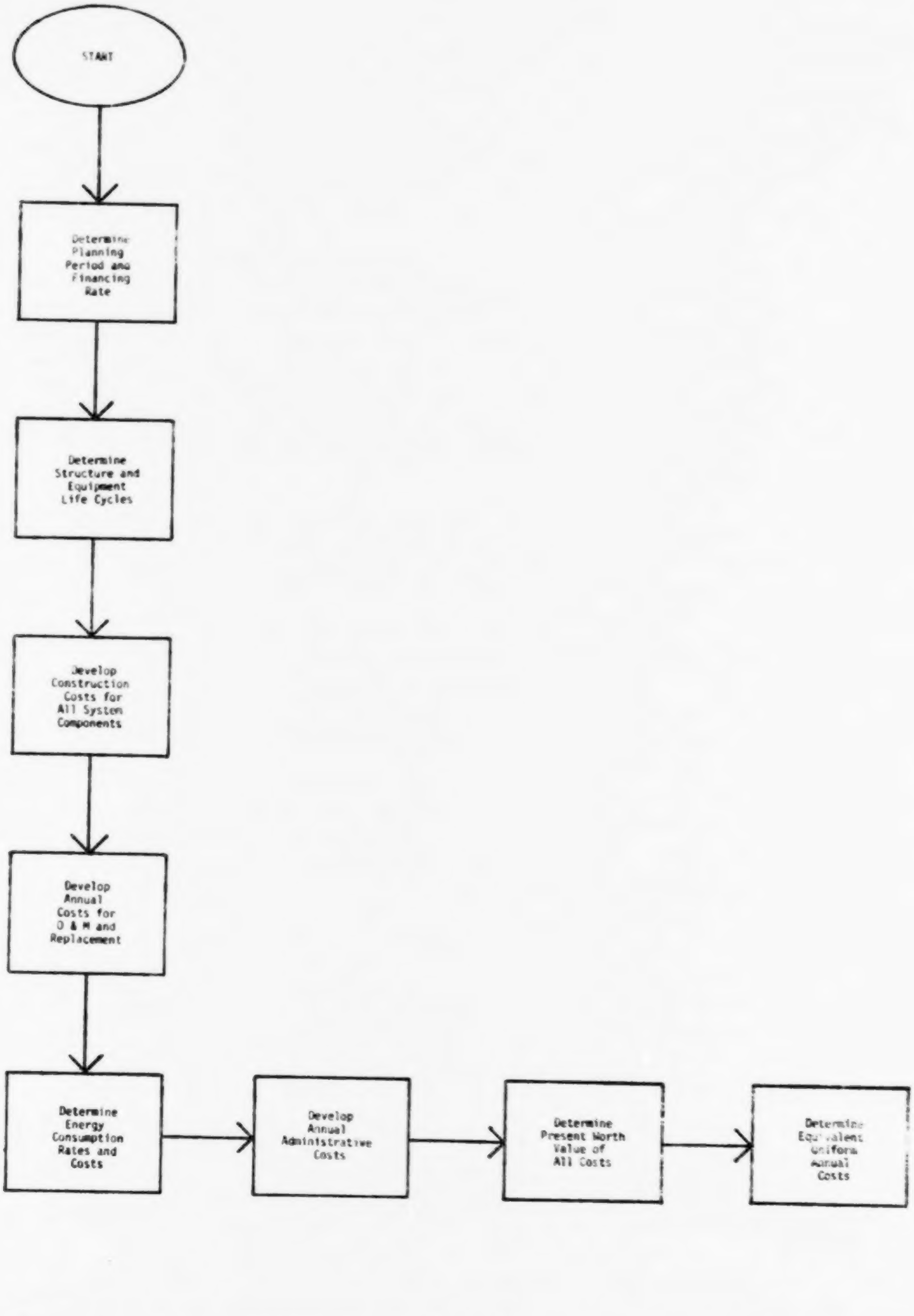

START
Determine Planning Period and Financing Rate
Determine Structure and Equipment Life Cycles
Develop Construction Costs for All System Components
Develop Annual Costs for O & M and Replacement
Determine Energy Consumption Rates and Costs
Develop Annual Administrative Costs
Determine Present Worth Value of All Costs
Determine Equivalent Uniform Annual Costs

Figure 4.2.2.5. Methodology for Identifying Additional Costs Incurred on Barrier Islands.

Source: Claude Terry & Associates, Inc. 1981

GRANT ELIGIBILITY IS DETERMINED BASED ON THE ESTIMATED ALLOWABLE BUILDING COSTS, SYSTEM COMPONENTS, HISTORICAL DEVELOPMENT PATTERNS AND SYSTEM TECHNOLOGY

Before October 1, 1984, the federal government will generally consider as eligible 75 percent of the cost of constructing cost-effective conventional collection lines if at least two-thirds of the service area was developed by October 1972. Thereafter, federal funding for collection systems ceases. The cost of treatment plants and major interceptor lines is eligible for 75 to 85 percent until October 1, 1984. Thereafter funding drops to 55 to 75 percent.

This section is a general summary of the requirements used to determine grant eligibility. A thorough review of all applicable regulations will usually be required to determine any specific eligibility.

The Clean Water Act of 1977 provides for federal funding for construction of approved wastewater management facilities. The level of funding varies depending upon the system components and must be carefully evaluated to determine total eligibility. Details of the grant eligibility question are addressed in EPA's Program Requirements Memorandums 78-9 and 79-8 and in EPA's Construction Grants 1982 and Facilities Planning 1982 now being printed. Because the facility costs across the nation exceed the level of funding authorized by Congress and changes in grant regulations continue, determination of eligibility does not insure that funding will be received. Conventional collectors are rarely fundable. The state's priority list will itemize all projects that are fundable.

Figure 4.2.2.6 shows that the first step in determining grant eligibility is to document the level of development existing in October 1972. If that level of development can be shown to account for more than two-thirds of the design flows, then the collection system may be eligible for funding. After September 30, 1984, the eligibility of all collection systems will expire except for state funding in special cases.

If the collection system is a cost-effective alternative technology and the community population is less than 3500, then the system is grant eligible for 85 percent of the costs for sites generating less than 94.75 $m^3d/$ (25,000 gpd) which were substantially inhabited by December 27, 1977. Conventional collection systems are grant eligible only if the two-thirds rule is met.

Treatment plants and major interceptors are grant eligible as long as they have been shown to be the most cost-effective system available. Publicly owned alternative or innovative treatment technologies are considered

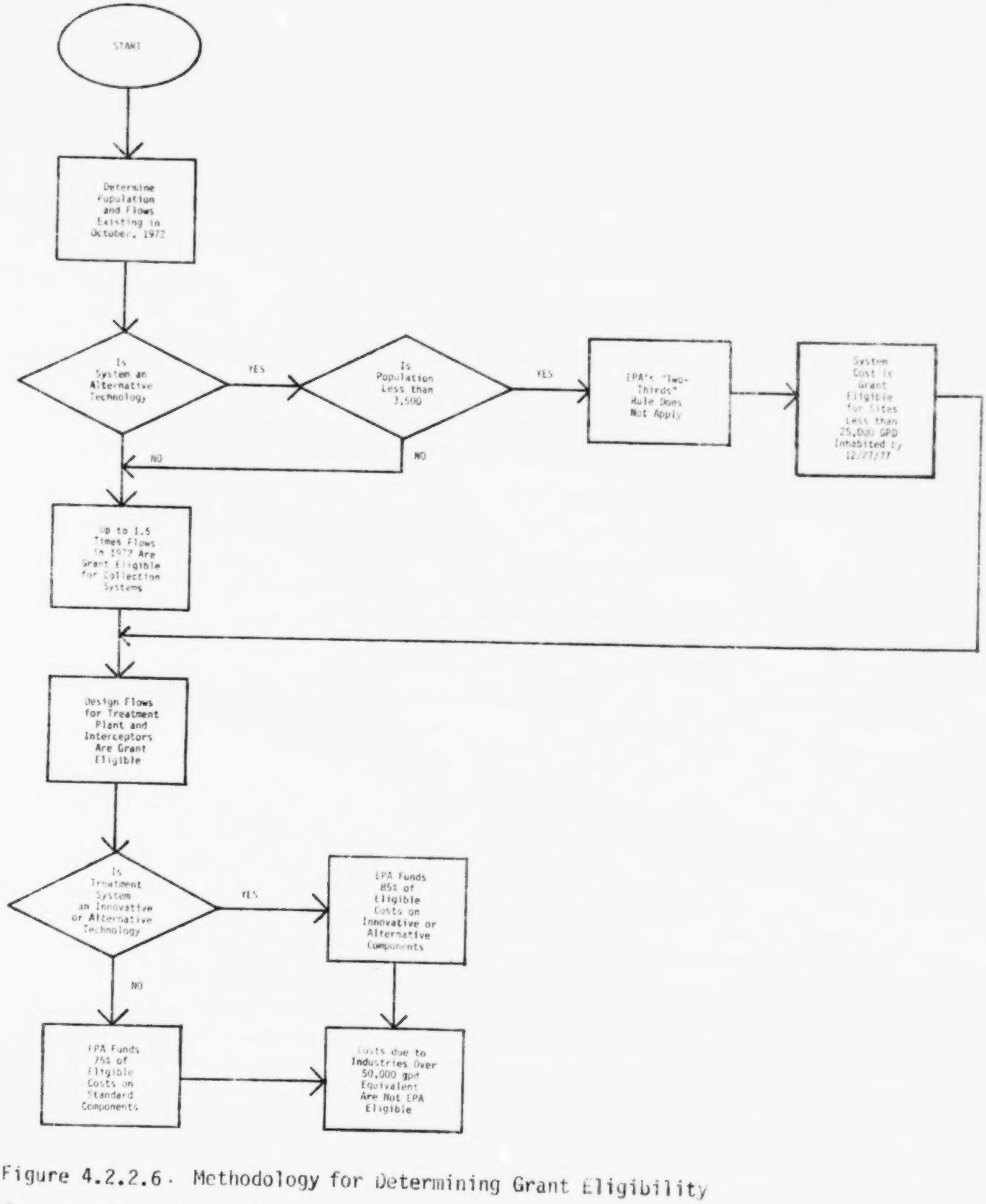

START
Determine Population and Flows Existing in October, 1972
Is System an Alternative Technology
YES
Is Population Less than 3,500
YES
EPA's "Two-Thirds" Rule Does Not Apply
System Cost Is Grant Eligible for Sites Less than 25,000 GPD Inhabited by 12/27/77
NO
NO
Up to 1.5 Times Flows in 1972 Are Grant Eligible for Collection Systems
Design Flows for Treatment Plant and Interceptors Are Grant Eligible
Is Treatment System an Innovative or Alternative Technology
YES
EPA Funds 85% of Eligible Costs on Innovative or Alternative Components
NO
EPA Funds 75% of Eligible Costs on Standard Components
Costs due to Industries Over 50,000 gpd Equivalent Are Not EPA Eligible

Figure 4.2.2.6. Methodology for Determining Grant Eligibility

Source: Gannett Fleming Corddry and Carpenter, Inc. 1981.

cost-effective if their cost does not exceed 115 percent of the cost-effective conventional method of treatment.

If the system components that are grant eligible are considered to be alternative or innovative technologies, then their federal funding will be 85 percent (75 percent after September 30, 1984) of the total cost. Conventional components that are grant eligible will only receive 75 percent (55 percent after September 30, 1984) federal funding. Costs due to industries generating over 189.5 m^3/d (50,000 gpd) equivalent are not grant eligible.

AN AGENCY MUST BE DESIGNATED TO RECEIVE 201 FUNDS AND ADMINISTER WASTEWATER MANAGEMENT SYSTEMS

An alternative can be successfully implemented only if the management agency nas adequate legal authority, technical expertise and management skills.

The implementability of a technical wastewater management alternative requires consideration of the legal and institutional requirements of each alternative system previously developed. In terms of legal constraints, state enabling legislation provides a far wider range of powers and authority to cities than are granted to unincorporated communities. The ability of a management agency to own real property, enter into contracts, set rates, receive grants, employ personnel, etc. are critical aspects of implementability.

Institutional considerations were not fully analyzed in most of the draft 201 Plans. Therefore, the EIS consultants have prepared a series of worksheets and other analytic tools to aid grant applicants in defining their institutional and financial constraints and developing optimum management alternatives. These tools will be presented in a series of workshops during the autumn of 1981.

Institutional considerations focus on what sort of management agency may receive 201 funds and administer wastewater management facilities. Where wastewater management is already a community service, an analysis of the effectiveness of the present management structure is the point of departure in determining whether existing institutional arrangements can be expected to adequately manage a new or upgraded system or whether a new mechanism needs to be devised.

Where wastewater management represents a new service, options must be explored as to whether the community should:

- Serve only itself
- Incorporate adjacent neighborhoods into its service area through its powers of extra-territorial jurisdiction
- Be served by a larger jurisdiction such as the county
- Make overtures to join another jurisdiction in a cooperative venture.

North Carolina law provides possibilities for a large number of institutional management options:

- A city utility or public works department
- A county utility or public works department
- A joint management agency
- A county service district

4.2.3 Continued

- A sanitary district
- A water and sewer authority
- A metropolitan water district
- A metropolitan sewerage district
- A private water and sewerage company

Two or more communities may sign an interlocal agreement whereby one of the parties provides services to all the communities. In a given 201 planning area, it is possible for more than one of the above agencies to be providing services.

Figure 4.2.3 presents a simplified methodology for selecting one or more feasible institutional management alternatives. The user should step through the methodology once for each technical alternative developed, consulting Table 4.2.3.2 where appropriate.

The following sections of the report discusses in greater detail the questions raised by Figure 4.2.3. These discussions are supplemented by a separately bound appendix, Implementing Wastewater Facilities Plans in the Barrier Island Region of North Carolina: Institutional and Financial Issues and Needs (Briscoe, Maphis, Murray & Lamont, Inc. 1981).

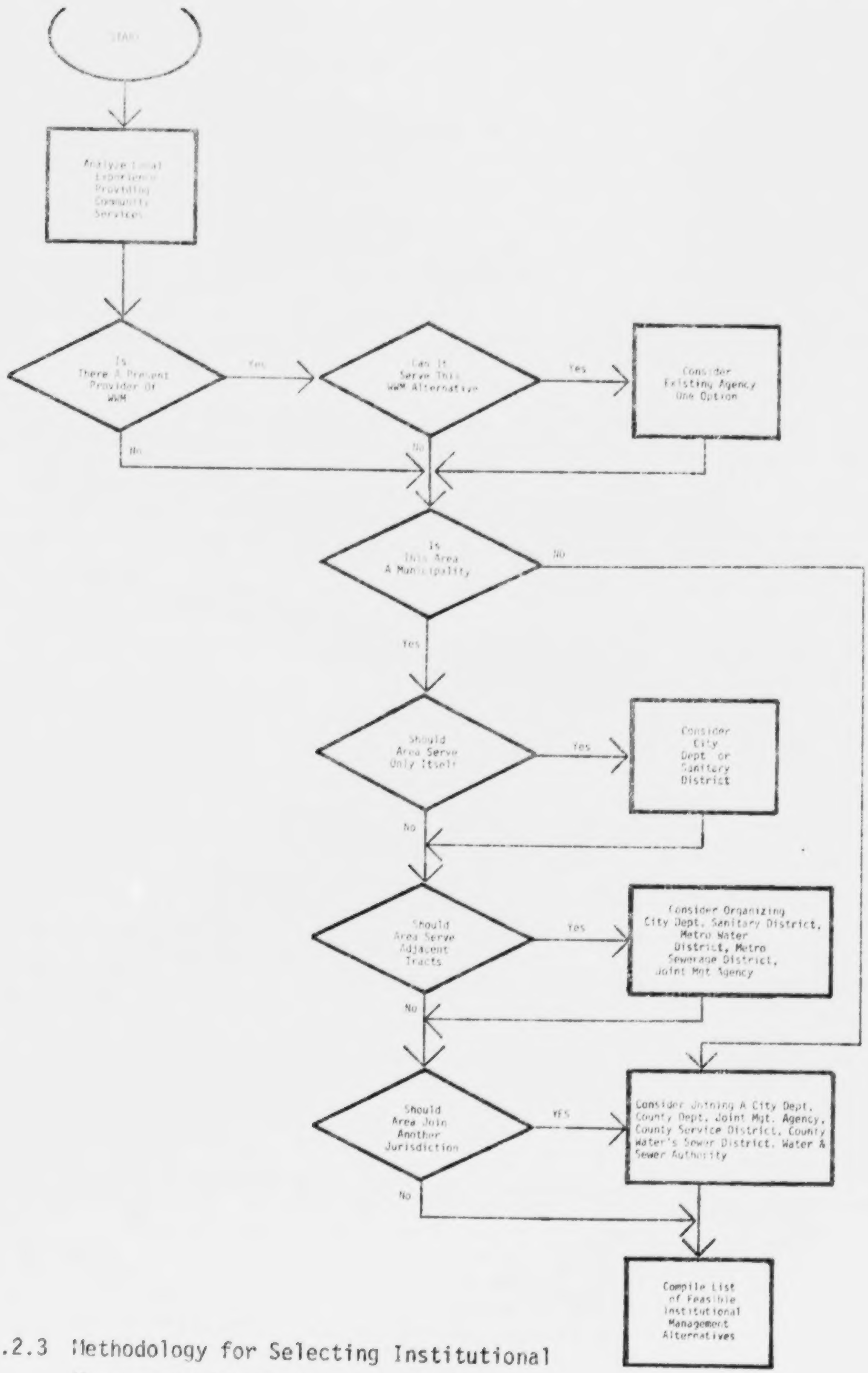

START
Analyze Local Experience Providing Community Services
Is There A Present Provider Or WWM
Yes
Can It Serve This WWM Alternative
Yes
Consider Existing Agency One Option
No
No
Is This Area A Municipality
No
Yes
Should Area Serve Only Itself
Yes
Consider City Dept. or Sanitary District
No
Should Area Serve Adjacent Tracts
Yes
Consider Organizing City Dept, Sanitary District, Metro Water District, Metro Sewerage District, Joint Mgt Agency
No
Should Area Join Another Jurisdiction
YES
Consider Joining A City Dept, County Dept, Joint Mgt. Agency, County Service District, County Water's Sewer District, Water & Sewer Authority
No
Compile List of Feasible Institutional Management Alternatives

Figure 4.2.3 Methodology for Selecting Institutional Management Alternatives for Each Technical Alternative

Source: Claude Terry & Associates, Inc., 1981.

4.0 DESCRIPTION OF ALTERNATIVE PROCEDURES DEVELOPED BY THE EIS

4.2 Procedures for Developing Alternative Wastewater Management Systems

4.2.3 Procedures for Developing Institutional Management Alternatives

4.2.3.1 Procedures for Analyzing Local Experience in Providing Community Services and Wastewater Management

DO LOCAL GOVERNMENTS POSSESS ADEQUATE STAFFS AND EXPERTISE FOR PROVISION OF WASTEWATER MANAGEMENT SERVICES?

Communities should assess their experience to date in providing community services in order to identify gaps in their capacity to provide the necessary level of wastewater management services in the future. The assessment aids each community in deciding whether to provide services or enter into a cooperative agreement with other jurisdictions.

Initially each community within a 201 planning area should analyze its experience in providing community services, particularly water supply and wastewater management. The results of the analysis will pinpoint management and administrative capability shortfalls and will have a direct bearing on a community's decision as to whether to provide wastewater management services alone or to seek to join another community in a customer/supplier relationship.

The following questions should be raised during the assessment of existing experience and capabilities:

- Does the community have on staff an adequate number of trained management and technical personnel to carry out the operation and maintenance of wastewater management systems? If not, what will be the range in size and cost of a new bureaucracy?
- Are sufficiently sophisticated recordkeeping systems in place to absorb the workload of wastewater management systems? Will the community be required to convert manual systems to computerized systems if the latter are not in place?
- Who can the community look to for technical assistance in establishing charges, designing bond issues and identifying specialized engineering or financial advice?

None of these questions may pose major obstacles to the larger barrier island communities. However, those communities with small resident populations may find that they do not possess or want to acquire the management capability (regardless of financial considerations) to undertake the provision of wastewater management services on the scale required to accommodate their large existing or projected seasonal populations. In such circumstances, local governments should explore cooperative ventures with other jurisdictions, particularly a customer-supplier relationship.

4.0 DESCRIPTION OF ALTERNATIVE PROCEDURES DEVELOPED BY THE EIS

4.2 Procedures for Developing Alternative Wastewater Management Systems

4.2.3 Procedures for Developing Institutional Management Alternatives

4.2.3.2 Checklist of Capabilities of Potential Management Agencies

DETERMINE WHICH TYPE AGENCY CAN MEET LOCAL FUTURE NEEDS

Each of ten management agencies is analyzed in terms of possible service area boundaries, ability to receive funds, ability to raise funds and voter responsiveness.

North Carolina statutes provide for at least ten management agency alternatives for the provision of wastewater management services. Given such a large number of options, each community should delineate its management needs in detail so as to be able to select the one or more most appropriate types of institutional arrangements for further consideration once a technical alternative has been chosen.

Table 4.2.3.2 provides yes/no answers to a series of key questions about the capability of each type of management agency. The section on voter responsiveness requires some explanation. The question as to whether service users have direct control of service providers via the ballot box is largely a question about whether the governing board of the agency is elected or appointed. In the case of a city department, city residents are voters who can influence agency activities, but service users outside the city limits cannot do so.

In identifying those agencies which might meet community needs, each community would want reasonable assurance of adequate input to the following:

- Guarantees of reserve capacity and allocation formulae
- Accommodation of new residents via the agency's extension policy
- Setting and changing rates
- Ownership of facilities
- Operation of facilities
- Requirements about hook-on of existing on-lot system users and passage of local ordinances where none exists

In large part the above issues would be resolved by the interlocal agreements which all parties would sign eventually. However, each community should decide at an early date its requirements in the resolution of these issues.

Table 4.2.3.2

Capabilities of Institutional Management Alternatives SERVICE PROVIDER CAPABILITIES	City Department	County Department	Joint Mgmt. Agency	County Service District	County Water & Sewer District	Sanitary District	Water & Sewer Authority	Metro Water District	Metro Sewerage District	Private Corporation
Service Area:										
1. Can serve more than one polit. jurisdiction within a county?	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Can serve less than a whole county?	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Can serve more than one county?	Y	Y	Y	N	N	Y	Y	N	Y	Y
Service area boundaries can be expanded?	Y	Y	Y	Y	N	Y	Y	Y	Y	Y
Finance: Raise Funds										
2. Can issue general obligation bonds?	Y	Y	N	Y	Y	Y	N	Y	Y	N
Can issue revenue bonds?	Y	Y	Y	Y	Y	Y	Y	Y	Y	N
Can impose assessments?	Y	Y	N	Y	Y	N	Y	N	N	N
Can levy property taxes?	Y	Y	N	Y	Y	Y	N	Y	Y	N
Can set fees, rates, charges?	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Finance: Receive Funds										
3. Can directly receive local option tax funds?	Y	Y	N	N	N	N	N	N	Y	N
Can directly receive HUD Community Development Block Grant funds?	Y	Y	N	N	N	N	N	N	N	N
Holds title to all real property of system?	YorN	YorN	N	YorN	YorN	YorN	YorN	YorN	YorN	Y
Can directly receive federal revenue sharing funds?	Y	Y	N	N	N	N	N	N	N	N
Voter Responsiveness										
4 Service users have direct control of service providers via ballot box?	Some	Y	N	Y	Y	Y	N	N	N	N
It is a unit of government?	Y	Y	N	N	Y	Y	Y	Y	Y	N
5. Single purpose agency?	N	N	YorN	N	N	N	N	N	Y	Y

Source: Compiled by Claude Terry & Associates, Inc., Atlanta, GA from the text of: University of North Carolina Water Resources Research Institute. 1980. Wastewat Management in Coastal North Carolina. Chapter IV.

4.0 DESCRIPTION OF ALTERNATIVE PROCEDURES DEVELOPED BY THE EIS

4.2 Procedures for Developing Alternative Wastewater Management Systems

4.2.3 Procedures for Developing Institutional Management Alternatives

4.2.3.3 Rationale for Public Management of On-Site and Community Systems

PUBLIC AGENCY CAN ASSURE PROPER OPERATION AND MAINTENANCE

Regulations pertaining to on-site and small community systems generally apply to design and construction but leave operation and maintenance responsibility to homeowners. Poor operation and maintenance is the leading cause of failure of these systems.

Poor operation and maintenance of on-site and small community systems is one cause leading to their failure. Public management of these systems is a possible means of ensuring that improper operation and maintenance does not contribute to system failure. Regulatory agencies generally do not set standards or specific requirements to ensure proper operation and maintenance. In general, local and state regulations are applicable to the design and construction of septic systems but leave the operation and maintenance responsibility to homeowners.

Enforcement officials corroborate research which has identified enforcement problems as the weak link that leads to ineffective management and malfunctioning systems. Such problems include the following:

- Many agencies lack time and resources to control on-site and small systems adequately
- Local authorities usually depend on the integrity and ability of soil testers and contractors to evaluate sites and to design and install systems
- Local authorities are sometimes pressured into approving the construction of septic systems on poor or marginal soils.

EPA's regulations now require that grantees ensure a fully adequate operation, maintenance, and management system for facilities funded, including on-site systems. To overcome these problems, a number of communities have opted for public management of on-site and small community systems. Public entities must have the authority to control these systems. Essential controls and the authority to enforce them are:

Control Element	Authority Needed
Siting and Design	To enter property and do in-depth site evaluations
Installation	To set design standards, review designs and inspect construction
Operation and Maintenance	To enter property to inspect and ensure proper operation and maintenance, including septic tank clean-out

4.2.3.3 Continued

Problem Correction	To require and enforce repair or replacement of failing systems

A public management agency can also be responsible for implementing certain measures which would further reduce the chance of failure of on-site systems:

- Initiate a project to analyze the causes of failure based on historical data and analyze each new failure reported. Identify trends in local as well as area-wide causes for failure. Use this information to anticipate future problems and respond with preventive maintenance activities in high risk neighborhoods.

- Establish a public education program. Develop a brochure for all homeowners using on-site systems describing the proper use of their systems and include it in their property tax bill or water bill, etc.

- Establish liaison with local planning departments. Ensure that zoning officials are furnished maps of areas of known failure and areas of high risk so that development densities in these areas can be held to the level that physical systems can sustain.

- Monitor groundwater to detect if nitrates are reaching the water table aquifer.

A MEANS OF FINANCING TECHNICAL ALTERNATIVES SHOULD BE DETERMINED

Financial management alternatives consider the issue of affordability: does the community possess the fiscal capacity to implement each of the technical alternatives? In addition, cost-sharing arrangements should be explored.

This section of the report addresses the steps a community should follow in reaching a decision about the affordability of each of the technical solutions to wastewater management problems previously documented. The issue of affordability focuses on the ability of the community both to raise capital as well as meet operating costs.

The development of financial management alternatives is a particularly important task since barrier island communities are characterized by highly fluctuating seasonal flows. The issue of user fees requires detailed examination. Several options are available to accommodate the incremental costs of providing capacity for seasonal users:

- Peak month(s) surcharge for all seasonal users
- Seasonal differential based on type consumer
- Seasonal differential based on type technology used.

The starting point is an analysis of the present financial status of the community. This analysis is described in detail in the next section of the report. Whether or not a community decides to serve itself, it should explore the alternative of cost-sharing schemes. These alternatives are discussed in Section 4.2.4.2. Figure 4.2.4 is a systems flowchart describing these analyses.

Additional financial issues which need to be examined include:

- Contingency plans if outside funding sources are not available

- Sensitivity analysis which measures the degree of uncertainty attached to assumptions about the financial implications of population projections, flow volumes over time, inflation, energy costs, costs of goods and services, etc.

- Refinements to the local taxation system so that system beneficiaries more directly bear the costs. Examples include the issues 1) should tourists be paying a larger share than they do presently and 2) the assurance that new growth pays its fair share.

Although the following sections focus on the development of financial management alternatives for central or regional treatment plants, the development of financial management alternatives for small community systems should not be overlooked. Since both the costs and the benefits are localized, either direct assessments or assessment bonds provide the most

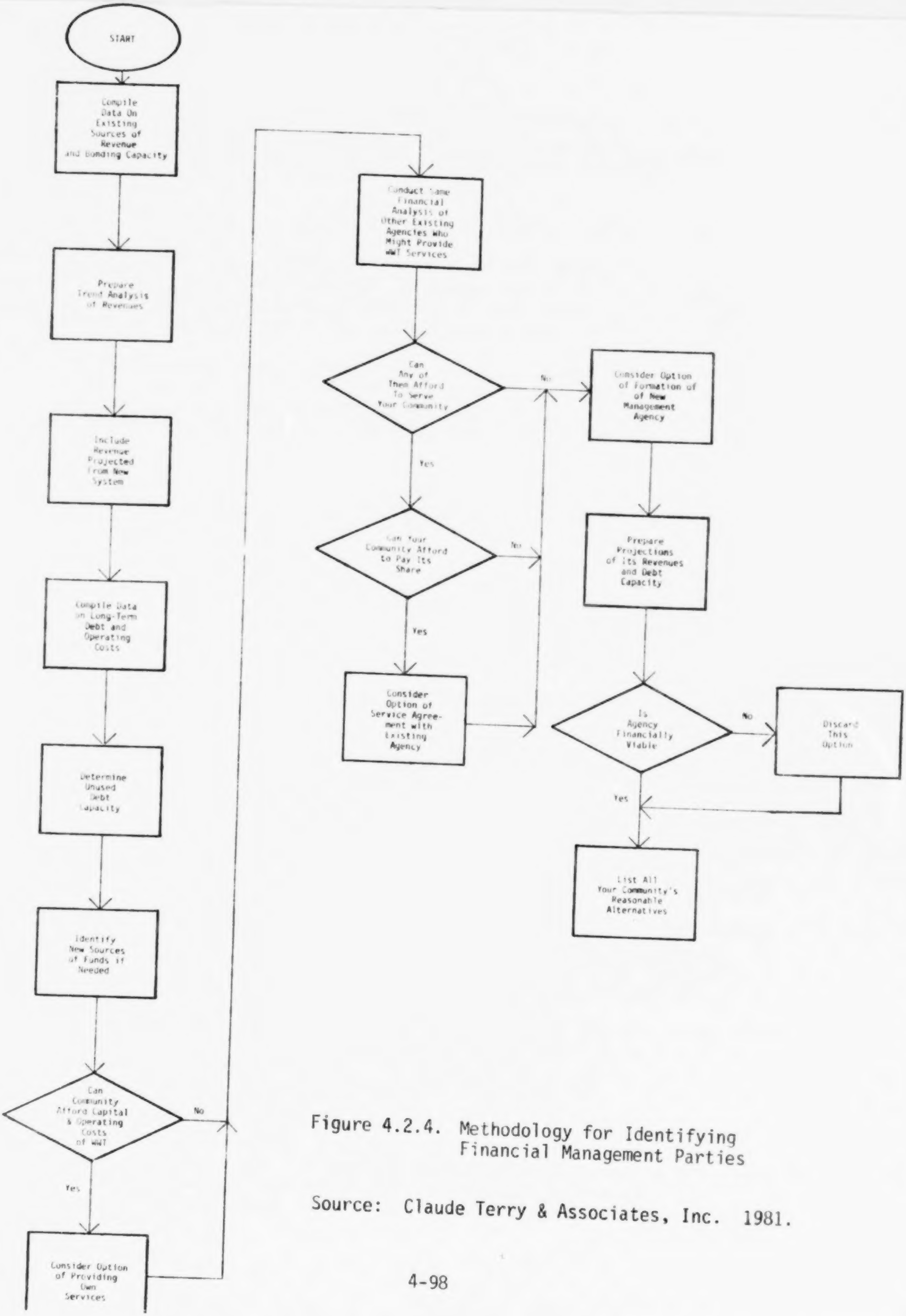

START
Compile Data On Existing Sources of Revenue and Bonding Capacity
Prepare Trend Analysis of Revenues
Include Revenue Projected From New System
Compile Data on Long-Term Debt and Operating Costs
Determine Unused Debt Capacity
Identify New Sources of Funds if Needed
Can Community Afford Capital & Operating Costs of WWT
No
Yes
Consider Option of Providing Own Services
Conduct Same Financial Analysis of Other Existing Agencies Who Might Provide WWT Services
Can Any of Them Afford To Serve Your Community
No
Yes
Can Your Community Afford to Pay Its Share
No
Yes
Consider Option of Service Agreement with Existing Agency
Consider Option of Formation of of New Management Agency
Prepare Projections of Its Revenues and Debt Capacity
Is Agency Financially Viable
No
Yes
Discard This Option
List All Your Community's Reasonable Alternatives

Figure 4.2.4. Methodology for Identifying Financial Management Parties

Source: Claude Terry & Associates, Inc. 1981.

reasonable financing mechanism in situations where wastewater management systems in areas of existing development need upgrading or replacing. In areas of future development where small community systems or individual on-site systems are appropriate, construction costs are routinely borne by the developer or individual homeowner.

Additional discussions about financial considerations can be found in a separately bound appendix, Implementing Wastewater Facilities Plans in the Barrier Islands Region of North Carolina: Institutional and Financial Issues and Needs (Briscoe, Maphis, Murray & Lamont, Inc. 1981).

4.0 DESCRIPTION OF ALTERNATIVE PROCEDURES DEVELOPED BY THE EIS
4.2 Procedures for Developing Alternative Wastewater Management Systems
4.2.4 Procedures for Developing Financial Management Alternatives

4.2.4.1 Procedures for Assessing the Community's Ability to Support a New Wastewater Management System

EACH TECHNICAL ALTERNATIVE MUST BE AFFORDABLE

Figures must be compiled and analyzed for 1) bonding capacity and sources of operating income and 2) long term debt and operating costs of the system. Shortfalls should be pinpointed and additional sources of funds identified. Thereafter, local officials can decide if the community can afford to provide wastewater management services. The draft plan of operation, required at the time of grant application, must include an adequate budget identifying the basis for determining the annual operation and maintenance costs and the costs of personnel, material, energy and administration.

Before a community can consider assuming additional long term debt or operating costs of a wastewater management system, it must first assess its present financial condition. An understanding of the existing resource base, current practices and commitments and fiscal capacity of the local government is essential.

Bonding Capacity and Sources of Operating Income

A wastewater management system will require capital outlays by local government. Costs will fall in the range of 25 percent (45 percent after September 30, 1984) state and local matching money for conventional wastewater management systems and 15 percent (25 percent after September 30, 1984) state and local matching money for alternative/innovative systems if the project qualifies for 201 Construction Grants Step 2 and Step 3 monies. If EPA selects the No Federal Action alternative, 100 percent state/local funding will be necessary.

The first step is to delineate the bonding capacity of the local government. Bonds may only be used to defray capital expenditures, not operating costs. By state law, local governments' total bonding capacity is set at eight percent of the total assessed property tax base. Both general obligation bonds and lease-purchase agreements (but not revenue bonds) are subject to the eight percent ceiling. The only exception to this provision is that when the North Carolina Environmental Management Commission or a court requires the implementation of wastewater treatment systems, general obligation bond debt is not subject to the eight percent net debt limit.

The next step is to compile data about existing sources of revenue which may legally be used to operate wastewater management systems. In North Carolina, these sources of income could include:

- Ad valorem (property) tax
- Local sales and use tax

4.2.4.1 Continued

- Business (privilege) license tax
- Local franchise tax
- Alcoholic Beverage Control tax
- User charges of existing wastewater treatment system, if any

A trend analysis of revenue sources should be prepared by individual source to identify which ones can be expected to increase and decrease, particularly in response to inflation.

Proposed tap-on fees and user charges should be reviewed to evaluate their economic and political acceptability. Each user charge system must include an adequate financial management system that will accurately account for revenues generated by the system and expenditures for operation and maintenance and replacement of the treatment system. EPA regulations require that the annual costs to users not exceed the following percentages of annual household median income (1979 dollars):

1.0% when median family income is under $10,000
1.5% when median family income is $10,000-$17,000
1.75% when median family income exceeds $17,000.

The affordability criteria should be applied only to the permanent residential population components and not include the seasonal components. If necessary, more realistic fees and charges should be developed. Thereafter, the income from proposed user fees should be computed and added to other sources of revenue.

Long Term Debt and Operating Costs

Operating costs projected by the 201 Plan should also be reviewed and compared against anticipated system revenues. If a deficit results, other sources of revenues which could serve to make up any differences between proposed user charges for the new system and actual costs should be evaluated.

Figures should also be compiled identifying the community's outstanding long term debt. Thereafter, an analysis of unused debt capacity should be made. Figure 4.2.4.1 summarizes this analysis for a hypothetical community. The histogram shows that between 1985 and 1987 the community's bonding capacity is not presently large enough to accomodate a wastewater management general obligation bond issue. The community's options include:

- Reducing the size of the bond issue by increasing tap-on fees
- Reassessing the property tax base to determine if the debt ceiling can be raised
- Considering the use of revenue bonds
- Exceeding the ceiling if implementation of the project is required by the North Carolina Environmental Management Commission or courts.

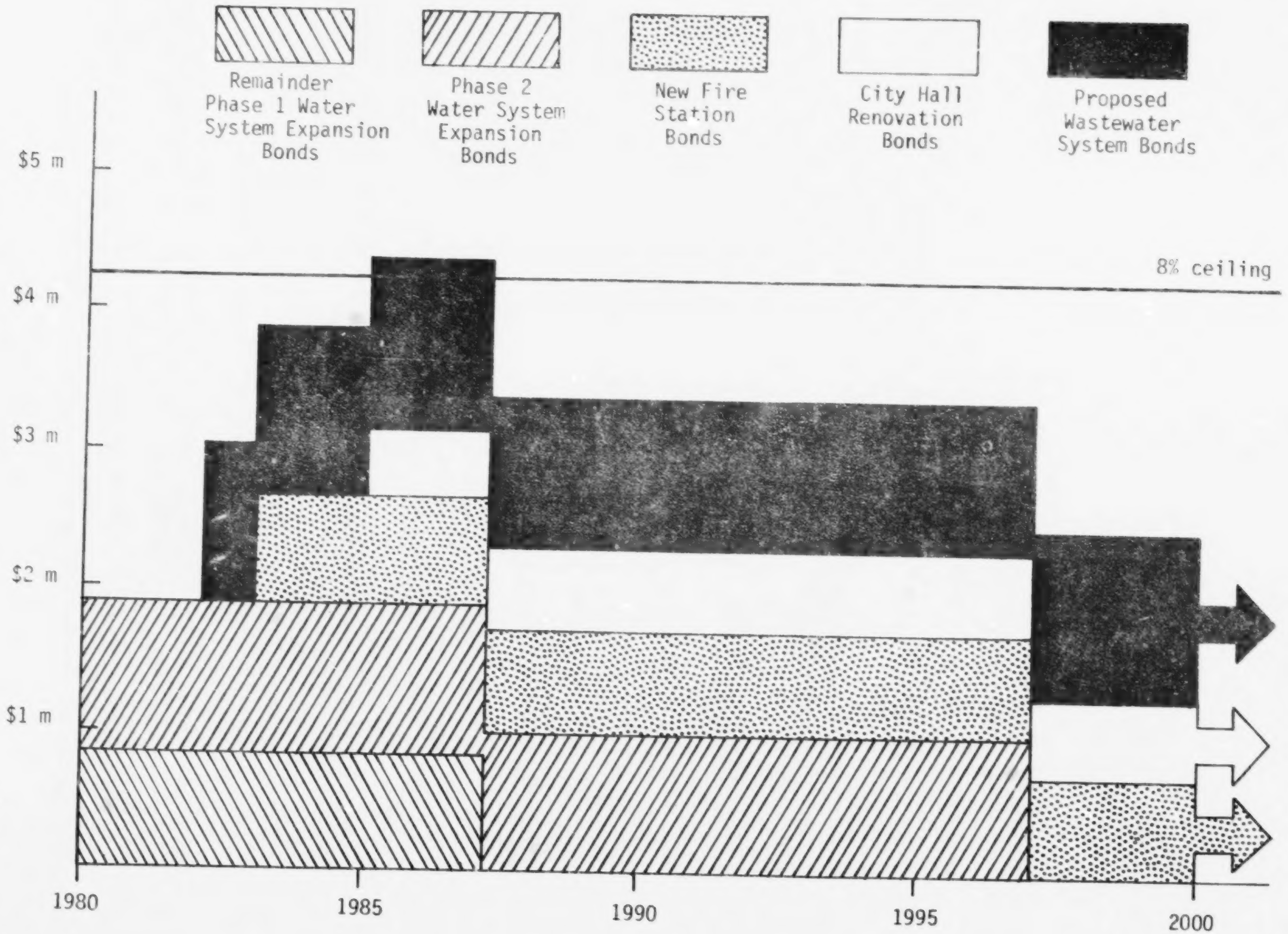


Figure 4.2.4.1 Histogram of Unused Debt Capacity for a Hypothetical Community

Source: Claude Terry & Associates, Inc., 1981

Identification of Additional Sources of Funds

If a shortfall is identified in either operating funds or the ability to finance capital costs, then new sources of funds need to be found. A shortfall in operating income generally results when the proposed user charges must be reduced and when subsidies from other revenue sources are not enough to make up the difference.

Assessment of Existing Fiscal Capability

Public hearings should be held to present the findings of the financial analysis to system users and gather their comments. Therefore, local officials can decide whether or not the community can afford the capital and operating costs of providing wastewater management systems. If the decision is negative, then community leaders should immediately investigate the costs of entering into a service agreement with an existing agency or new agency. Even if the community can afford to serve itself, the analysis of other financial management alternatives should proceed to the investigation of all reasonable alternatives. This analysis is discussed in Section 4.2.4.2.

4.2.4.2 Procedures for Assessing the Feasibility of Multiple Party Management Agency Alternatives

COMMUNITIES SHOULD EXPLORE COST-SHARING ALTERNATIVES

In cooperative arrangements, the issues revolve around the financial capability of the supplier agency to provide services and the ability of the customer agency to meet its share of joint and individual costs.

In considering possible customer-supplier relationships, the first step is to identify those existing agencies in the 201 planning area, if any, which provide wastewater management services. The same type financial analyses should be performed as described in the preceeding section of the report. The purpose of the initial analysis is to ascertain if any existing agencies have the fiscal capability to serve additional jurisdictions and at what cost. Thereafter, the customer community must determine if those costs are affordable.

Section 4.2.3.2 discussed the institutional management capabilities of a variety of agencies. Therefore, the financial feasibility of service delivery by any new agencies previously identified as appropriate for one or more technical solutions should be investigated. Detailed projections of bonding capacity, revenues and levels of debt service should be made.

The issue of equity in allocating costs in any cost-sharing arrangement should be addressed at this time. Questions include:

- What elements of the multi-jurisdictional system are eligible for allocation?
- What costs are to be borne solely by individual communities?
- What is the formula for determining cost allocations?
- What administrative procedures should be implemented to assure that costs can be reallocated as appropriate?

4.0 DESCRIPTION OF ALTERNATIVE PROCEDURES DEVELOPED BY THE EIS

4.2 Procedures for Developing Alternative Wastewater Management Systems

4.2.5 Procedures for Developing Total Wastewater Management Systems Alternatives

ALL REASONABLE WASTEWATER MANAGEMENT SYSTEMS MUST BE DEVELOPED TO
INSURE THAT THE MOST VIABLE SYSTEM HAS THE OPPORTUNITY
TO BE EVALUATED

After the wastewater management requirements of an area are determined, the appropriate technologies for the area have been developed and the cost of such technologies itemized, all logical management system alternatives must be evolved.

Figure 4.2.5-a graphically depicts the evolutionary process that developing reasonable wastewater management systems appropriate for a given area requires. This task is begun by assessing all appropriate technologies applicable to any given service area and then to all groups of areas that can be reasonably grouped by logical service areas. Initially the development of logical service areas is a process of grouping areas by a common technology such as septic tanks and soil absorption systems. The objective of this portion of the process is to develop as many different technically feasible wastewater management systems as can be reasonably expected to handle the requirements of each service area. Figure 4.2.5-b illustrates this process.

Having generated a list of all feasible technologies appropriate for the area, operational and financial management schemes then have to be developed for each of the feasible technologies. The management scheme for each technology will have to consider the political jurisdictions involved, the ownership of the properties and treatment facilities involved, legal or statutory restraints and on how the particular technology will be financed (will there be grant funding?).

In its simplest form, a technology might be that of individual septic tanks and soil absorption fields for each housing unit. This would result in the minimum involvement of governing bodies, since the individual homeowner will finance, construct and operate his own facilities. The cognizant governing agencies will only have to permit, inspect and regulate the siting, construction and use of the facilities. In the case of a regional treatment system that treats wastewater from two different towns, the management scheme becomes much more complex in that special arrangements have to be developed to provide for the financing, construction and operation of the facilities. These arrangements have to include solutions to such questions as each town's responsibility for operating the system. In some instances, enabling legislation will have to be adopted by each town to allow such a scheme. All such issues should have solutions presented for each operational management scheme being suggested for each feasible technology.

The financial management schemes that have to be developed for each feasible technology are also varied in complexity. The simplest technology is the privately owned on-site systems such as the septic tank and soil absorption system. In this instance the individual owning the system would

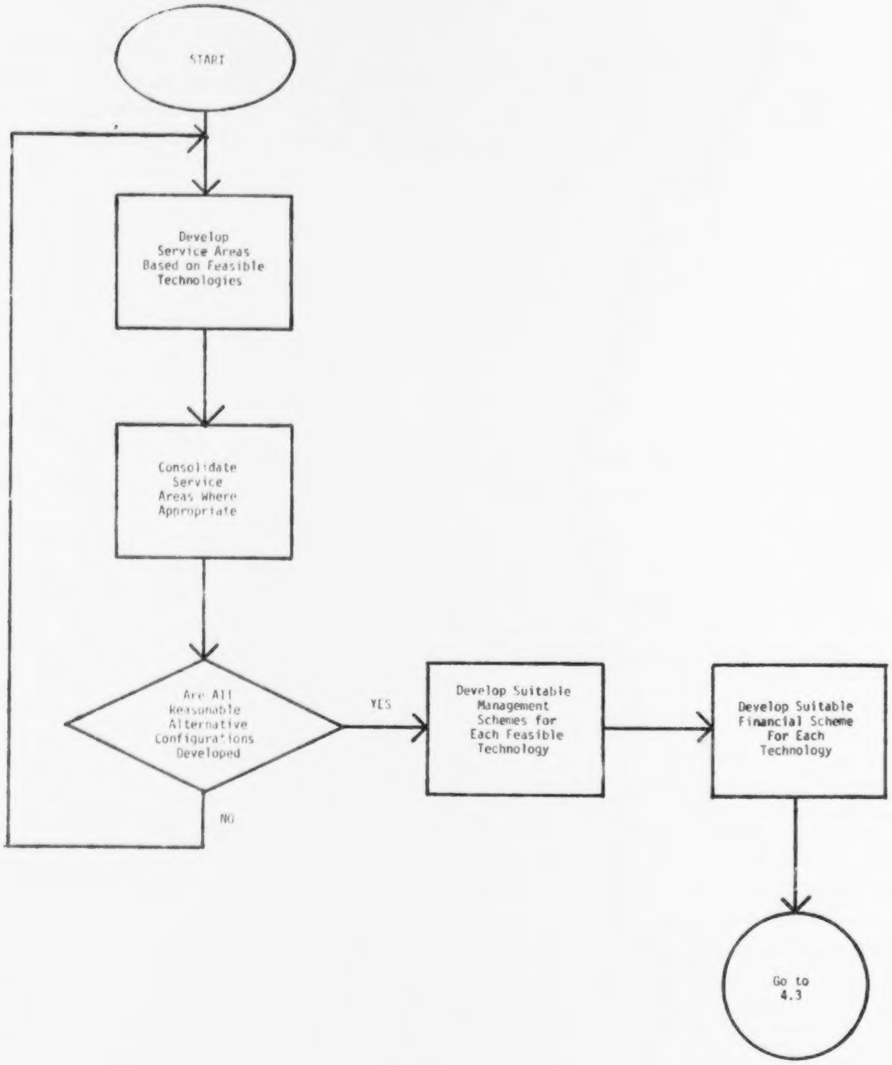
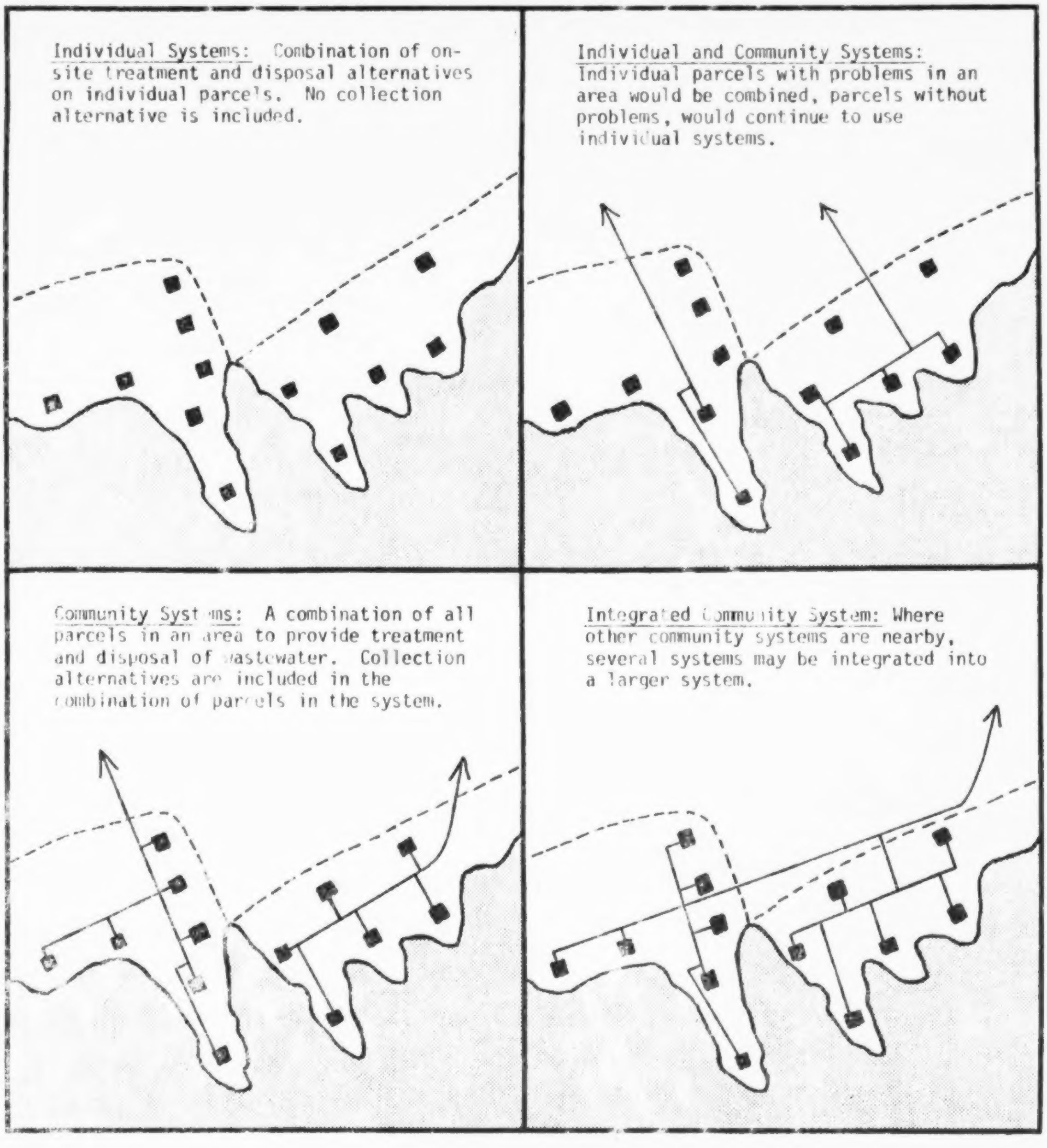

START
Develop Service Areas Based on Feasible Technologies
Consolidate Service Areas Where Appropriate
Are All Reasonable Alternative Configurations Developed
YES
NO
Develop Suitable Management Schemes for Each Feasible Technology
Develop Suitable Financial Scheme For Each Technology
Go to 4.3

Figure 4.2.5-a. Methodology for Developing Total Wastewater Management System Alternatives

Source: Claude Terry & Associates, Inc., 1981

Figure 4.2.5-b. Conceptual Representation of Community Wastewater System Alternative Possibilities.



Individual Systems: Combination of on-site treatment and disposal alternatives on individual parcels. No collection alternative is included.

Individual and Community Systems: Individual parcels with problems in an area would be combined, parcels without problems, would continue to use individual systems.

Community Systems: A combination of all parcels in an area to provide treatment and disposal of wastewater. Collection alternatives are included in the combination of parcels in the system.

Integrated Community System: Where other community systems are nearby, several systems may be integrated into a larger system.

Note: Combined flows go to community, central or regional treatment system.

SOURCE: Adapted from "EPA Final Environmental Impact Statement Buckingham, Pennsylvania Wastewater Treatment Facilities" August 1981.

4.2.5 Continued

provide all construction and operation costs with the governing agencies funding the cost of permitting, inspecting and regulating the use of the system. It is also possible that some form of community-wide management organization funded by local governing jurisdictions could operate and maintain individual on-site systems. Additionally, individual septic tank and soil absorption systems could be provided, operated and maintained by a wastewater management utility for a monthly fee. Wastewater management systems that include transportation and treatment either in community, central or regional treatment schemes require more complex methods in determining how the systems will be funded for acquisition, operation and maintenance of the system. The object of the exercise to develop all possible alternative wastewater management systems for a 201 planning area necessitates that each of the feasible technologies be accompanied by a feasible institutional and financial management scheme.

AN ANALYSIS OF PROS AND CONS CAN GUIDE LOCAL OFFICIALS IN SELECTING WASTEWATER MANAGEMENT SYSTEM

Each alternative must be evaluated with regard to its costs, environmental impacts, local financial impacts, susceptibility to storm damage and any other relevant criteria. Procedures for assessing each factor and summarizing the results are contained in this section of the report.

This section of the report focuses on evaluating the total wastewater management systems that were developed by carrying out the procedures presented in previous sections of Chapter 4.0. Several alternatives will have been developed, each with a technical, institutional and financial component. The next step, therefore, is to evaluate each alternative with regard to those criteria upon which system selection depends:

- Cost
- Primary and secondary environmental impacts
- Local financial impacts
- Susceptibility of systems to storm damage
- Other criteria.

The following sections contain procedures for conducting each of the above evaluations. The evaluation of each criteria within each alternative is conducted in two phases. The first phase involves the documentation of impacts. The second phase addresses the significance of the impact. Numerous techniques exist for evaluating significance. Some are very complex and subject to considerable manipulation. Other methods are very simple and consist of nothing more than displaying impacts in tabular form, organized as "pro" and "con" with regard to supporting wastewater management systems which are cost-effective and environmentally sound.

Local officials are now in position to make a selection from among the evaluated total wastewater management systems alternatives. Political judgement will be combined with the technical assessments to identify the alternative which best meets the needs of the community.

Political judgement is defined as an evaluation of the public acceptability of the proposed wastewater management system. A full scale public participation program is an essential activity when any major 201 Plan re-evaluations are undertaken. Such a program is required by 40 CFR Parts 25 and 35; February 16, 1979). Special procedures should be devised to reach property owners and regular renters, who would be substantially affected by changes in user charges. At a minimum, letters should be sent to all permanent and seasonal residents who are property owners.

EVALUATING ENVIRONMENTAL IMPACTS AID IN DETERMINING FEASIBILITY OF WASTEWATER MANAGEMENT SYSTEMS

Each alternative system developed must be evaluated with regard to primary and secondary environmental impacts. Worksheets have been prepared to help present the assessment in an organized form.

Impacts may be primary, produced by the construction, operation and maintenance of the system, or secondary, derived in some fashion from the existence of the system and its capacity. These effects are also termed direct and indirect, respectively. Impacts may be characterized as short term (construction noise) or long term (loss of a species of fish or committment of a land area for 20 years). The short or long term nature of the impact may be important in decision-making, since impacts acceptable to local populace on a short term basis are frequently not acceptable indefinitely. Impacts must also be considered either positive or negative. Effort expended in estimating impacts accurately may be extremely beneficial, since positive benefits not initially forseen may emerge, or potentially severe adverse impacts can be avoided, mitigated or at least foretold.

The magnitude of impacts should be estimated. In some cases, quantification of the impact is possible (for example, "a shellfish bed yielding 10,000 lbs/yr can be reopened" or "100 acres of lowland hardwood forest will be lost"). However, quantification can be deceptive when applied to systems where the impacts differ only in degree. Arbitrary numerical quantification of magnitude may lead to reliance on small differences in numbers which are individually not really quantifiable. The use of positive and negative descriptions can provide a range of identification without the use of numbers in arbitrary situations. Figure 4.3.1 is a flowchart showing the steps necessary to complete this assessment.

Table 4.3.1 is an example of a worksheet which can be used to evaluate environmental impacts. The entries on the worksheet should describe in narrative form the impacts of the proposed wastewater management system alternative on the natural or manmade environmental resource. A section of the worksheet should be completed for each system alternative. Thereafter, the worksheets may be laid side by side so that comparisons can be made about the differences in impacts between alternatives.

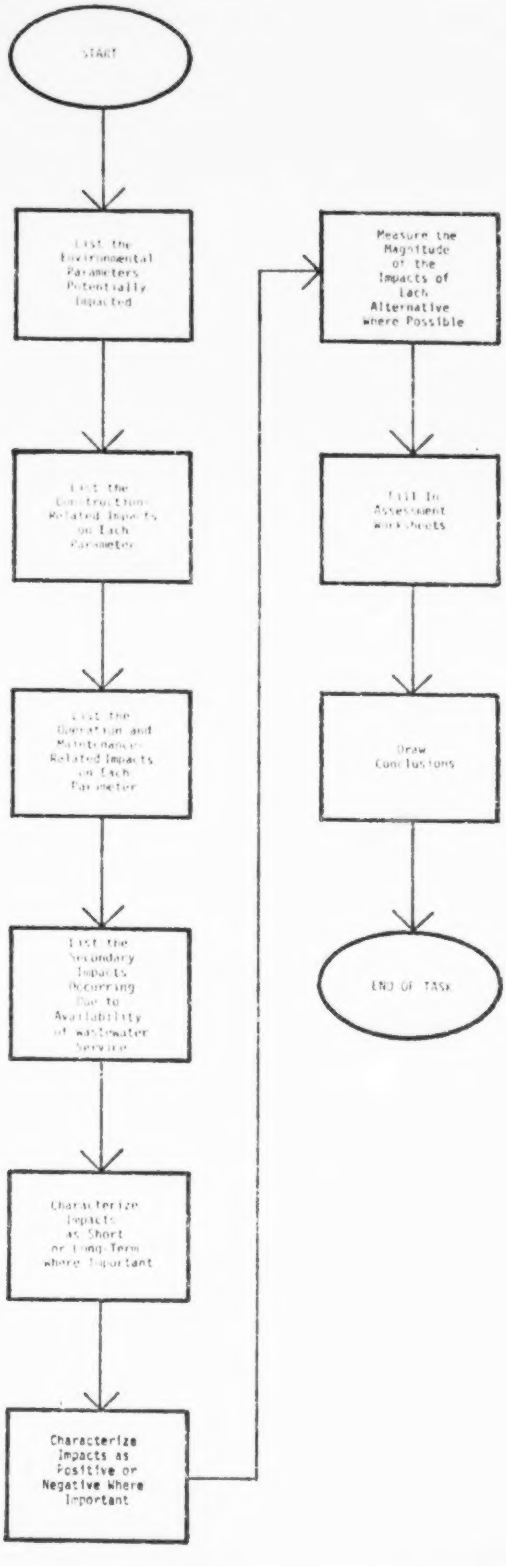

START
List the Environmental Parameters Potentially Impacted
List the Construction-Related Impacts on Each Parameter
List the Operation and Maintenance-Related Impacts on Each Parameter
List the Secondary Impacts Occurring Due to Availability of Wastewater Service
Characterize Impacts as Short or Long-Term where Important
Characterize Impacts as Positive or Negative Where Important
Measure the Magnitude of the Impacts of Each Alternative where Possible
Fill In Assessment Worksheets
Draw Conclusions
END OF TASK

Figure 4.3.1. Methodology for Evaluating Primary and Secondary Environmental Impacts of Wastewater Management Systems.

Source: Claude Terry & Associates, Inc., 1981

Table 4.3.1 Environmental Impact Assessment Worksheet

Environmental Parameter	Alternative 1	Alternative 2	Alternative n
	Impact	Impact	Impact
Natural Environment			
Air Quality			
Odor			
Noise			
Threatened & Endangered Species			
Terrestrial Ecosystems			
Aquatic Ecosystems			
Soils			
Topography			
Geologic Resources			
Groundwater Quality			
Groundwater Quantity			
Surface Water Quality			
Surface Water Quantity			
Manmade Environment			
Population			
Land Use			
Public Health			
Economics/Employment			
Archeological/Historical Resources			
Natural Resource Utilization			
Recreation			
Transportation			
Community Services & Facilities			

Source: Claude Terry & Associates, Inc. 1981.

LOCAL FINANCIAL IMPACTS ARE MINIMIZED BY THE AMOUNT OF COSTS WHICH CAN BE EXTERNALIZED

An evaluation sheet has been designed to pinpoint the degree of impact on community finances of both capital costs and operating costs of each alternative. Risk assessment is also included in the evaluation process.

Section 4.2.4 contained a procedure for identifying a series of viable financial management alternatives. Some of these potentially affordable alternatives were combined with various technical and institutional management alternatives in Section 4.2.5 in order to structure a set of total wastewater management alternatives. The purpose of this section is to develop procedures which allow each financial management alternative selected in Section 4.2.5 to be evaluated as to its impact upon the community and compared against each of the other financial management alternatives.

Significantly different financial impacts can be experienced at the local level, given several wastewater management alternatives. Much depends upon the degree to which costs are internalized or externalized. The selection of systems eligible for state or federal grants externalize many costs. Requiring tourists to pay their share of systems costs externalizes a large portion of what would otherwise be a local burden. Dependence on the ability to externalize costs can be dangerous for a community; provision must be made for the eventuality that state or federal funds may not be forthcoming.

Evaluation of financial impact is a matter of both the size of the financial committment involved relative to the community resource base as well as the financial risk involved in the undertaking. Risk assessment is often overlooked, particularly a systematic identification of downside risk. Risk analysis should seek to pinpoint areas of uncertainty, and various types of sensitivity analysis described below are important tasks in the overall evaluation of financial impacts to local communities. Therefore, an initial task in screening all wastewater management alternatives should be the identification of what percent of life cycle total costs are capital costs (relatively firm, up front dollars) and what percent are operating costs (annual projections over 20 years).

The financial impacts of both the capital costs and operating costs of each alternative must be assessed. Table 4.3.2 is a questionaire which should be filled out for each alternative. The following discussion elaborates upon the questions raised in Table 4.3.2.

Capital Cost Evaluation

1. How close to the net eight percent ceiling does each alternative bring the community's total bonded indebtedness? However, when bonds are issued by the county, an authority or a district, the city's bonded indebtedness is not affected.

Table 4.3.2 Local Financial Impacts Questionaire

Question

I. How close is the community to the net 8 percent ceiling if this alternative is implemented?

   a. No impact on indebtedness or more than 11% margin remaining after adding on new debt

   b. Within 0-5% of margin

   c. Within 6-10% of margin

   d. Over ceiling with state permission

II. For how many years will the city be at its debt capacity?

   a. No impact on indebtedness or not at ceiling

   b. 1-2 years

   c. 3 years or more

III. What other capital improvement opportunities are foregone and how urgent are they?

Name of Improvement	Priority

IV. Will issuing of wastewater management bonds reduce attractiveness of other local bond issues?

V. If project revenue shortfall occurs, what will be the impact of debt service demands on property taxes and user fees?

   a. Negligible

   b. Moderate

   c. Severe

VI. How sensitive is this alternative to the projected numbers of dwelling units not actually being built?

   a. Negligible

   b. Moderate

   c. Severe

Table 4.3.2 Continued

VII. If an operating revenue shortfall occurs, how available are other sources to cover the deficit?

  a. Readily available

  b. Moderately available

  c. Limited

VIII. How sensitive are operating costs to

  a. Projected flow volumes

    1. Negligible

    2. Moderate

    3. High

  b. Inflation

    1. Negligible

    2. Moderate

    3. High

  c. Energy cost and availability

    1. Negligible

    2. Moderate

    3. High

  d. Scarce raw materials

    1. Negligible

    2. Moderate

    3. High

Source: Claude Terry & Associates, Inc. 1981.

4.3.2 Continued

2. If the city issues bonds, for how many years (if at all) will the debt capacity be at its ceiling?

3. By issuing wastewater management bonds, what other capital improvements opportunities are foregone? Parks? Public safety department plant and equipment? Commercial district revitalization?

4. How urgent are the city's other capital needs?

5. Will the issuing of wastewater management bonds reduce the attractiveness of bonds issued by other local jurisdictions, such as the Board of Education, etc.?

6. If project revenues cannot meet annual debt service needs, what will be the increase to property taxes and/or user charges? For some alternatives, the amount necessary to make up the shortfall may prove economically or politically unacceptable.

7. What will be the financial impact if the projected numbers of dwelling units are not built? How sensitive is the alternative to a smaller than projected amount of tap-on fees? This question applies to central and regional systems since on-lot systems do not involve tap-on fees and a reduction in number of dwelling units built out is not germane.

Operating Cost Evaluation

1. If project revenues cannot fully pay operating costs, to what degree are other revenue sources available to pay for the shortfall? A number of sources could support a deficit at a central or regional treatment plant. However, a small community system's resource base is much smaller and largely confined to system users; thus, it has few sources of outside revenue.

2. The operating costs of each alternative should be assessed for sensitivity to changes in projected flow volumes, inflation, energy costs and availability, and scarcity of raw materials. Some systems will be highly dependent upon certain flow volumes being achieved in order to insure financial stability. Inflation will play a variable role depending upon the percent of budget attributable to labor costs, replacement parts, chemicals, etc. and the rate at which each of these items increases in cost. Some wastewater treatment processes are more energy intensive than others and the need for pumping stations plays a major role in energy costs. The need for any raw materials that are presently or are anticipated to be in short supply (and therefore expensive) due to third world political upheavals or natural disasters should be identified.

After a questionaire has been completed for each alternative, a matrix which summarizes answers (similar to Table 4.3.1) should be prepared and analyzed.

EVALUATION OF SYSTEM SUSCEPTIBILITY TO STORM DAMAGE CONSIDERS DEGREE OF CENTRALIZATION, AMOUNT OF EXPOSED STRUCTURE AND ABILITY TO ASSIMILATE LOWER QUALITY EFFLUENT

A process that evaluates the system's susceptibility to storm damage is used to assist in the evaluation of a system's total reliability. This procedure involves an analysis of a system's components so as to develop a comparative ranking of systems. The process considers the following system characteristics: degree of centralization, amount of exposed structure and ability to assimilate lower quality effluent.

Historic records and borings on the barrier islands suggest that over time inlets have opened and disappeared over virtually the entire length of the islands from Virginia to Beaufort (Pilkey 1978). Similarly, several recent publications (Dolan et al. 1980, Leatherman 1979) suggest that the extensive saltmarsh areas are largely derived from and nourished by storm overwash of the islands. Rogers (1981) points out, however, that not all North Carolina barrier islands are low, narrow dunes rapidly migrating toward the mainland. Some much more stable islands with areas of substantial elevation, well developed maritime forests and other geologic features show no evidence of wave overwash or migration in the last 5,000 years.

The ongoing rise in sea level, coupled with storms, has generated extensive local beach erosion/deposition problems. Recent storms on other barrier islands (e.g., Dauphin Island, Alabama) have shown that both on-site and centralized systems can be dislocated by storm events.

Most of North Carolina's barrier islands have experienced major hurricanes and other storms within the last 30 years which approximated or exceeded reasonable design conditions for a 100 year (1 percent chance of occurrence each year) storm (Rogers 1981). The northeast storm of 1962 had a major impact north of Cape Hatteras. Hurricane Donna particularly impacted the Bogue Banks region in 1960. Hurricane Hazel approached design conditions in New Hanover and Pender Counties, substantially exceeding design conditions in Brunswick County. Photography, surveys and other records have documented shoreline changes and structural damages.

Rogers (1981) states that the general types of shoreline change and structural failures on barrier islands have been consistantly repeated over the years. On a barrier island some degree of gradual continuing long-term erosion is likely. The expected rate varies greatly from place to place, but the average for the developed areas is on the order of 0.61 m (2.0 ft) per year. Statewide, the average rate is roughly 1.0 m (3.28 ft) per year. Erosion rates will be considerably higher near inlets and generally independent of dune height.

4.3.3 Continued

Major storm impacts will be controlled by existing dune development and general topography. Ocean water levels will rise approximately 1.5-3.0 m (5.0-10.0 ft) above normal high tide. Substantial dune erosion will occur as far as 15.0-60.0 m (50.0-200.0 ft) landward. Oceanfront buildings in this region may experience waves 3.0 m (6.5 ft) in height, often less. Buildings not constructed on a deep piling foundation or not elevated above the waves will be severely damaged or destroyed. Elevated structures will experience relatively minor wind damage. If the barrier island has sufficient elevation to prevent overtopping by waves, damage to the highland areas will be relatively modest. Localized winds in excess of design speeds as well as falling trees and flying debris will be the major causes of structural damage.

Along barrier beaches with low elevation and small dunes, the areas immediately landward of the erosion zone will be buried by .3-1.2 m (1.0-4.0 ft) of sand carried landward by overtopping waves. The deposition zone may be 30.0-150.0 m (100.0-500.0 ft). Buildings on shallow piles (2.0-2.5 m (6.0-8.0 ft) below grade) elevated above waves will receive minimal damage. Most low buildings will be substantially damaged. Farther from the ocean, the next zone inland will resemble riverine flooding. Waves will generally be less than 1.0m (3.0 ft). Low elevation structures will be flooded or floated off their foundations, but elevated structures will have a high survival rate.

Existing inlet areas can expect higher rates of shoreline erosion, typically 10.0-33 m (30-100 ft) per year, sometimes consistently moving in one direction sometimes fluctuating around a central inland body of water. New inlet formation is a very real threat at a few sites but should not be perceived as a substantial threat to most of the developed areas (Rogers 1981).

Based on the above discussion, it is recommended that when planning and designing a particular wastewater management system, storm and erosion susceptibility of the various elements and of the entire system must be considered. Historical records should be examined for trends in erosion, deposition, overwash or inlet formation in the 201 area. Structure siting and collection system layouts should be designed to avoid either the use or crossing of hazardous areas or designed to withstand such eventualities.

When determining the susceptibility of the various wastewater management system alternatives to damage from storms, three system characteristics of the alternatives should be considered:

- Degree of centralization
- Amount of exposed structure
- Ability of systems to assimilate lower quality effluent

Degree of Centralization

When evaluating the effect of centralization on system susceptibility, each system alternative may be classified into one of the following categories:

4.3.3 Continued

- Individual treatment and disposal
- Individual treatment and community disposal
- Community treatment and disposal
- Regional treatment and disposal.

The assumption is that the more centralized a system is, the more likely general inconvenience and public health problems will occur due to the extensiveness in the disruption of service from storm damage. Therefore, the least centralized system (the on-site individual system) provides the most protection in that it serves a very small area and is not significantly affected by damage in areas outside its service area.

Amount of Exposed Structure

When evaluating the amount of exposed structure, the system alternatives may be classified as follows:

- Underground, few structural components, with subsurface disposal
- Underground, many structural components
  (Treatment systems include septic tanks, aerobic tanks, buried filters and holding tanks)
- Above ground, few structural components
  (Treatment systems include lagoons and marsh/pond systems; disposal systems include lagoons and spray irrigation facilities)
- Above ground, many structural components
  (Treatment systems include package plants, sewage treatment plants and oxidation ditches; disposal systems include ocean outfalls)

The assumption is that the more a system is exposed and structure-intensive, the more susceptible that system is to storm damage. This damage would result in a financial impact on the users for repairing or replacing the facilities. Storm damage to above ground facilities is assumed to result from high winds, strong rainfalls and flood inundation, whereas storm damage to underground facilities is normally due to high soil saturation levels that flood the systems. An example of the latter case is surface seepage from soil absorption systems and "pop-outs" of septic tanks and holding tanks after heavy rainfalls. In considering the amount of exposed structure, attention must also be given to the strength of the structure in resisting damage. A good example of this concern would be spray irrigation systems, which are quite susceptible to wind damage.

Ability of Systems to Assimilate Lower Quality Effluent

Lower quality effluent is a result of temporary impairment or temporary destruction of the treatment/disposal capabilities of the system. The systems are classified based on inherent storage capabilities in the treatment facilities relative to flow volumes. Treatment facilities with large storage capacity include lagoons, oxidation ditches, septic tanks, marsh/pond systems and sewage treatment plants with flow equalization. Treatment facilities with negligible storage capacity include aeration tanks, package plants, ocean outfall and sewage treatment plants without flow equalization.

4.3.3 Continued

The assumptions made for this evaluation are as follows:

1. Treatment facilities with large storage capacity can hold back low quality effluent until the total system is repaired and the wastewaters can receive the treatment required.

2. Ocean outfall disposal techniques can assimilate low quality effluent on a temporary basis without causing significant public health problems or environmental impacts. A temporary closing of the beaches to swimmers may result due to aesthetics and minor health concerns, but this affects only recreational concerns and only on a short-term basis. The important factor in this assumption is the large assimilation capacity of the ocean.

3. Inland surface water disposal is very sensitive to quality of discharged effluent due to its very low assimilation capacity, proximity to shellfish beds, and nexus with groundwater potable water supplies.

Table 4.3.3 is a worksheet that should be used to assess susceptibility to storms. Each alternative should be rated regarding degree of centralization, amount of exposed structure and ability to assimilate lower quality effluent. More detailed analysis of the amount of exposed structure may be undertaken on a component-by-component basis (tanks, drainfields, buried pipe, exposed pipe at bridge crossings, pump station, rotary distributors, etc.). After each alternative receives its three ratings, the composite scores can be compared to assess level of risk.

Table 4.3.3. Methodology for Evaluating the Susceptibility to Storm Damage for Each System Alternative.

System Characteristic	Classification of Systems	Level of Susceptibility		
		Low	Mod.	High
1. Degree of Centralization	Individual treatment and disposal	X		
	Individual treatment and community disposal		X	
	Community treatment and disposal		X	
	Regional treatment and disposal			X
2. Amount of Exposed Structure	Underground, few structural components	X		
	Underground, many structural components		X	
	Above ground, few structural components		X	
	Above ground, many structural components			X
3. Ability to Assimilate lower quality effluent	Treatment System			
	Large storage capacity	X		
	Negligible storage capability			X
	Disposal Method			
	Subsurface, land application		X	
	Surface, land application	X		
	Inland surface water discharge			X
	Ocean outfall	X		

Source: Gannett Fleming Corddry and Carpenter, Inc. 1981.

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APPENDICES

WASTEWATER MANAGEMENT SYSTEM SELECTION CRITERIA

Appendix A. Supplemental Bibliography

Appendix B. Details of Wastewater Management Options

Appendix C. Wastewater Treatment Alternatives Engineering Design Criteria

Appendix D. Wastewater Management System Selection Criteria

Table 1	Criteria for Determining the Suitability of Sites for On-Site Subsurface Soil Absorption Systems
Table 2	Individual On-Site Treatment/Disposal Systems
Table 3	Community Collection Systems
Table 4	Community Treatment/Disposal Systems
Table 5	Regional Collection Systems
Table 6	Regional Treatment/Disposal Systems
Table 7	Sludge/Septage Handling and Disposal Systems

Appendix E. On-Lot Wastewater Treatment and Disposal System Siting Criteria-
Dr. A.R. Rubin, North Carolina Agricultural Extension Service

APPENDIX A
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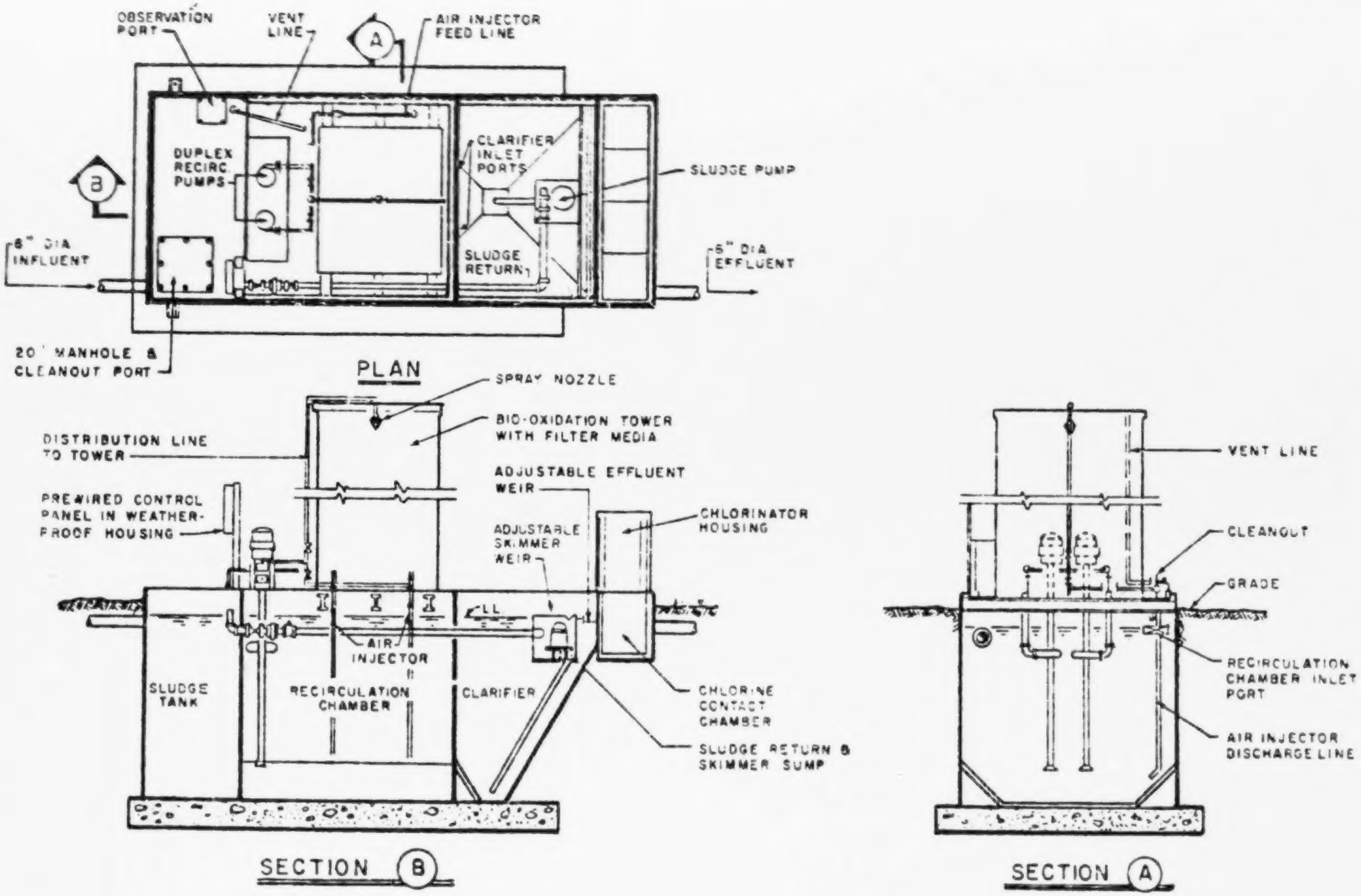
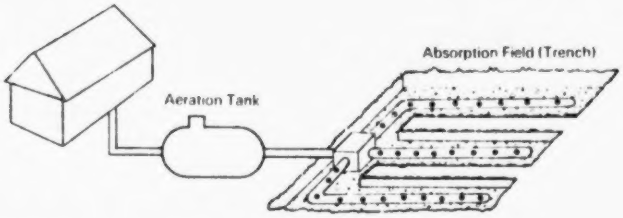
APPENDIX B
DETAILS OF WASTEWATER MANAGEMENT OPTIONS


OBSERVATION PORT
VENT LINE
A
AIR INJECTOR FEED LINE
B
DUPLEX RECIRC. PUMPS
CLARIFIER INLET PORTS
SLUDGE PUMP
8" DIA INFLUENT
SLUDGE RETURN
6" DIA EFFLUENT
20" MANHOLE & CLEANOUT PORT
PLAN
SPRAY NOZZLE
BIO-OXIDATION TOWER WITH FILTER MEDIA
DISTRIBUTION LINE TO TOWER
ADJUSTABLE EFFLUENT WEIR
PREWIRED CONTROL PANEL IN WEATHER-PROOF HOUSING
CHLORINATOR HOUSING
ADJUSTABLE SKIMMER WEIR
LL
AIR INJECTOR
SLUDGE TANK
RECIRCULATION CHAMBER
CLARIFIER
CHLORINE CONTACT CHAMBER
SLUDGE RETURN & SKIMMER SUMP
SECTION B
VENT LINE
CLEANOUT
GRADE
RECIRCULATION CHAMBER INLET PORT
AIR INJECTOR DISCHARGE LINE
SECTION A

Extended filtration package plant. USEPA "Process Design Manual—Wastewater Treatment Facilities for Sewered Small Communities" October 1977.

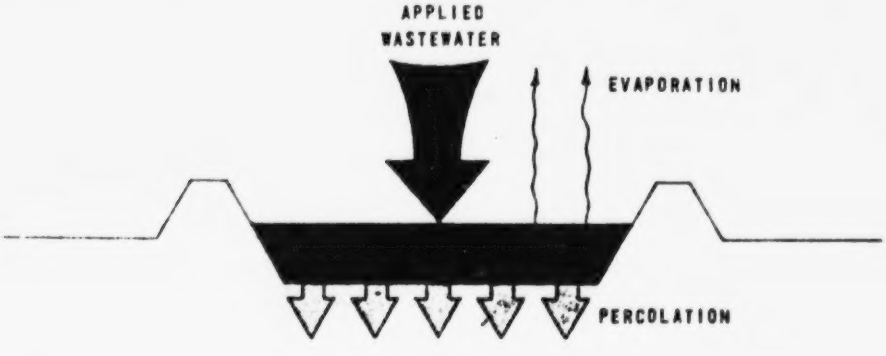
Air and wastewater are mixed in tank. Oxygen-using (aerobic) bacteria grow, digest sewage, liquefy most solids. Liquid discharges to absorption field where treatment continues. Can use same treatment & disposal methods as septic tank. Maintenance essential. Uses energy.



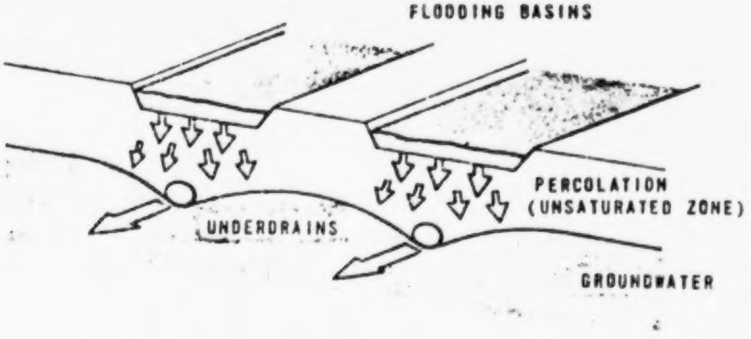
Aerobic system and soil absorption field

Source: USEPA Small Wastewater Systems "Alternative Systems for Small Communities and Rural Areas"

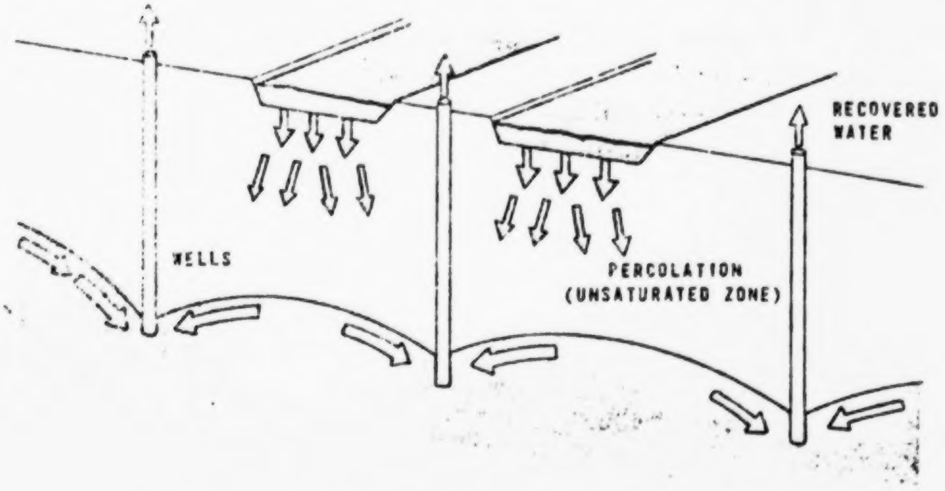
RAPID INFILTRATION


APPLIED WASTEWATER
EVAPORATION
PERCOLATION

(a) HYDRAULIC PATHWAY


FLOODING BASINS
PERCOLATION (UNSATURATED ZONE)
UNDERDRAINS
GROUNDWATER

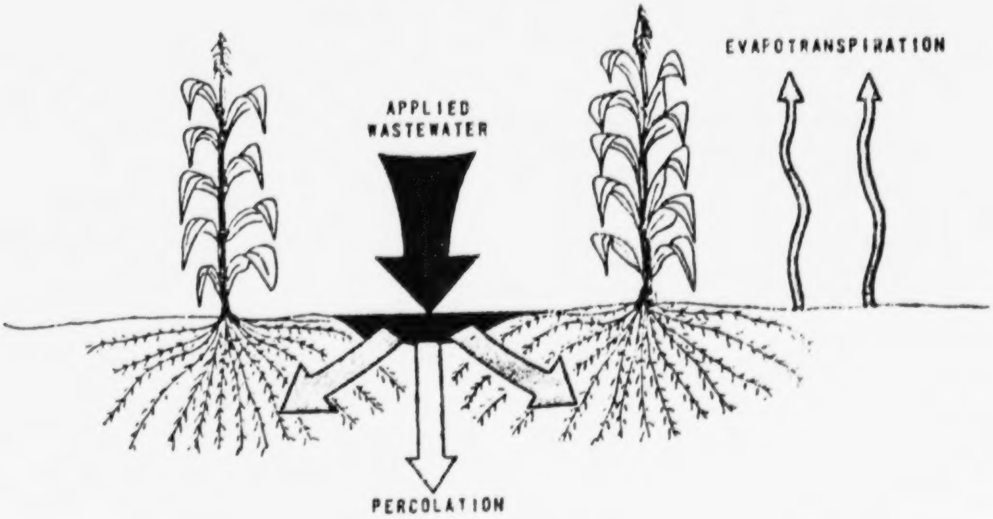
(b) RECOVERY OF RENOVATED WATER BY UNDERDRAINS


RECOVERED WATER
WELLS
PERCOLATION (UNSATURATED ZONE)

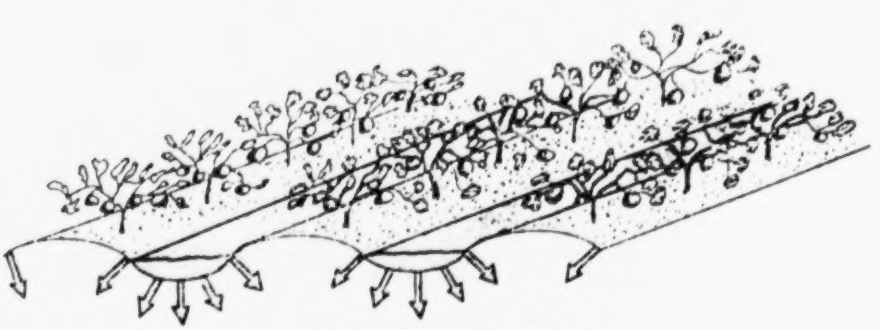
(c) RECOVERY OF RENOVATED WATER BY WELLS

Source: USEPA Technology Transfer "Process Design Manual for Land Treatment of Municipal Wastewater"
October 1977.

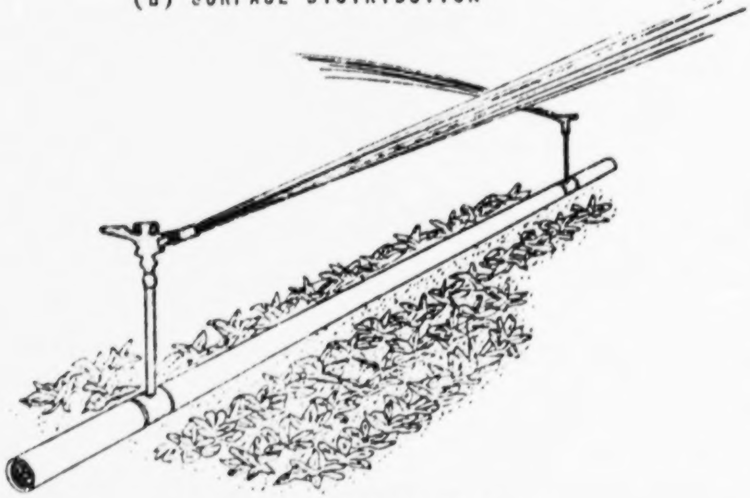
SLOW RATE LAND TREATMENT


APPLIED WASTEWATER
EVAPOTRANSPIRATION
PERCOLATION

(a) HYDRAULIC PATHWAY



(b) SURFACE DISTRIBUTION



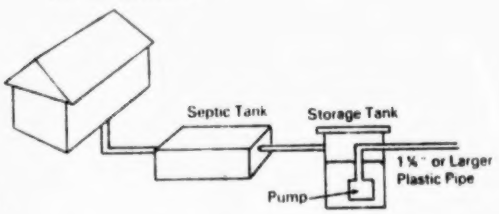
(c) SPRINKLER DISTRIBUTION

Source: USEPA Technology Transfer "Process Design Manual for Land Treatment of Municipal Wastewater"
October 1977

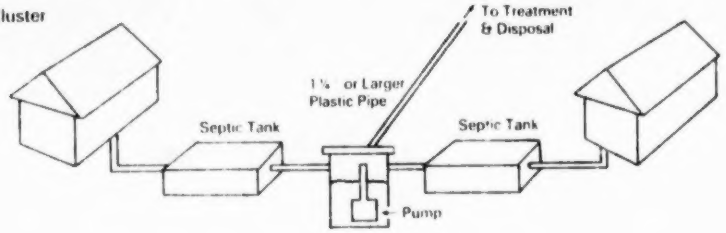
(A) One dwelling. Pump forces liquid from septic tank through plastic pipe to further treatment & disposal. Sludge is pumped from septic tank periodically.

(B) Cluster system. Liquid from several septic tanks flows to one pumping tank. Pump forces liquid through plastic pipe to treatment & disposal.

(A) One Dwelling


Septic Tank
Storage Tank
1¼" or Larger
Plastic Pipe
Pump

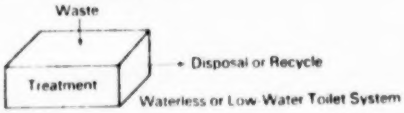
(B) Cluster


To Treatment
& Disposal
1¼" or Larger
Plastic Pipe
Septic Tank
Septic Tank
Pump

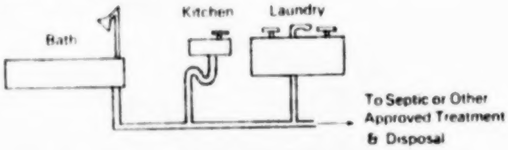
Pressure Sewers, STEP (Septic tank effluent pump)

Many systems. In this one: (A) toilet wastes (blackwater) are handled by waterless or low-water toilet system
(B) Other household wastewater from kitchen, bath, laundry (graywater) needs separate treatment & disposal.

(A) Blackwater (Toilet Wastes)


Waste
Treatment
Disposal or Recycle
Waterless or Low-Water Toilet System

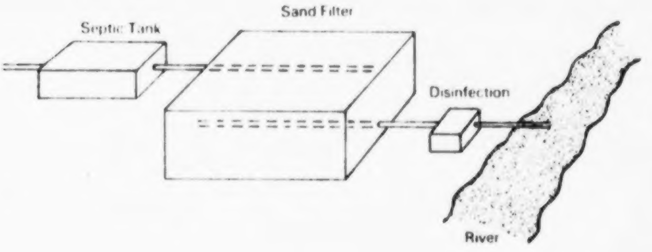
(B) Graywater (Other Household Wastewater)


Bath
Kitchen
Laundry
To Septic or Other
Approved Treatment
& Disposal

Dual Systems: Blackwater and Graywater

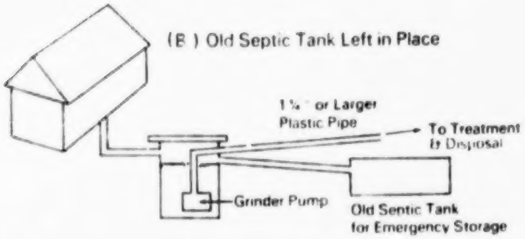
Source: USEPA Small Wastewater Systems "Alternative Systems for Small Communities and Rural Areas"

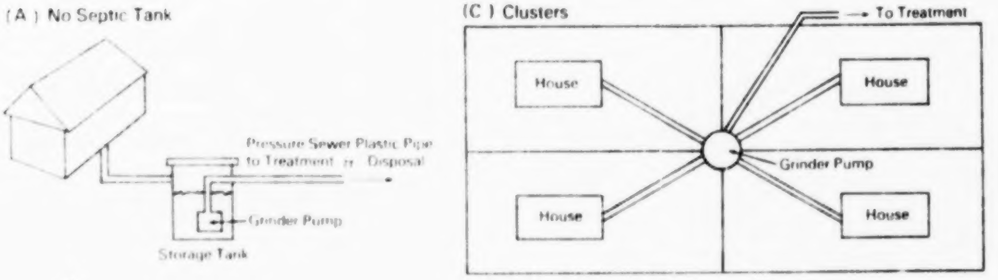
Filter is ground-level or buried sand pit. Liquid enters perforated pipe at top & filters through sand & gravel to bottom pipe. Bottom pipe conducts liquid to disinfection tank. Liquid discharges to stream or ditch. Variations are intermittent sand filter & recirculating sand filter. Used where soil absorption field not possible.


Septic Tank
Sand Filter
Disinfection
River

Septic tank, sand filter, disinfection and discharge

Unit grinds sewage & pumps it through small-diameter plastic pipe to central or alternative treatment & disposal. Doesn't use septic tank but existing tank (B) may remain for emergency storage. Used for one or several homes (C).

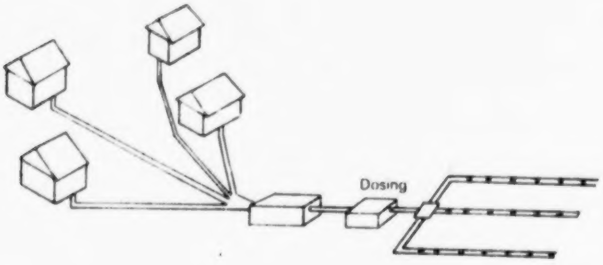

(B) Old Septic Tank Left in Place
1¼" or Larger Plastic Pipe
To Treatment & Disposal
Grinder Pump
Old Septic Tank for Emergency Storage


(A) No Septic Tank
Pressure Sewer Plastic Pipe to Treatment or Disposal
Grinder Pump
Storage Tank
(C) Clusters
To Treatment
House
House
Grinder Pump
House
House

Pressure sewers, GP
(Grinder Pump)

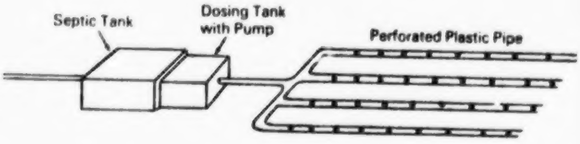
Source: USEPA Small Wastewater Systems "Alternative Systems for Small Communities and Rural Areas"

Several houses are served by common treatment and disposal system. Houses could also have onsite septic or aerobic tanks with liquid conducted to common absorption field. Clusters of houses can also use other alternative systems, such as mounds, pressure and vacuum sewers and sewage treatment lagoons.



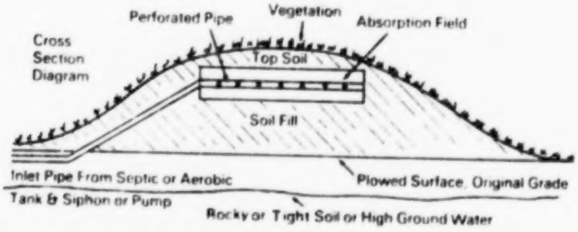
Cluster system
(two or more users on one alternative system)

Network of small-diameter perforated plastic pipes are buried 6"-18" in 4"-6"-wide trenches. Pump forces liquid through pipes in controlled doses so liquid discharges evenly. Site and soil determine pipe layout and pipe-hole size and number. Absorption field is same size as conventional field. Rocky or tight soil or high water table.


Septic Tank
Dosing Tank with Pump
Perforated Plastic Pipe

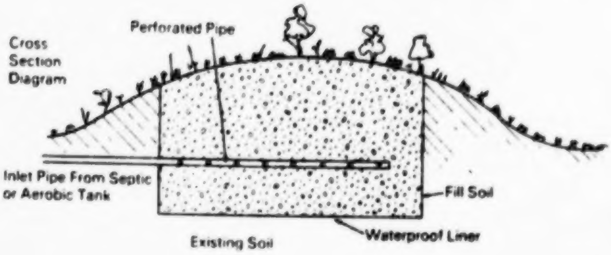
Low-pressure subsurface pipe distributio

Liquid is pumped from storage tank to perforated plastic pipe in sand mound that covers plowed ground. Liquid flows through rocks or gravel, sand, and natural soil. Mound vegetation helps evaporate liquid. Rocky or tight soil or high water table.


Cross Section Diagram
Perforated Pipe
Vegetation
Absorption Field
Top Soil
Soil Fill
Inlet Pipe From Septic or Aerobic Tank & Siphon or Pump
Plowed Surface, Original Grade
Rocky or Tight Soil or High Ground Water

Mound system
(used with septic or aerobic tank)

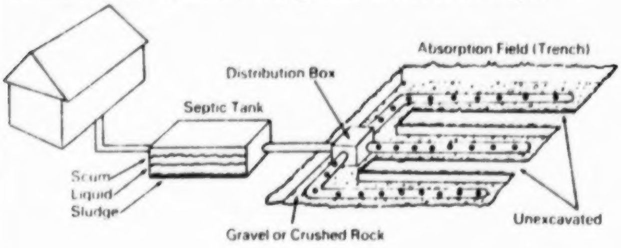
Sand bed is lined with plastic or other waterproof material. Bed could be mound or level. Liquid evaporates because liner prevents it from filtering through natural soil. Plants speed evaporation by drawing moisture from soil and breathing it into the air. Used where conventional absorption field not possible.


Cross Section Diagram
Perforated Pipe
Inlet Pipe From Septic or Aerobic Tank
Fill Soil
Waterproof Liner
Existing Soil

Evapotranspiration bed
(used with septic or aerobic tank)

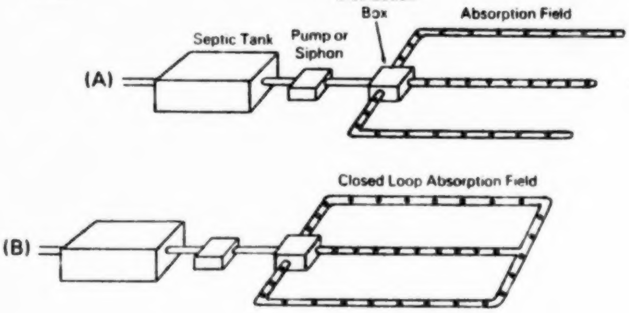
Source: USEPA Small Wastewater Systems "Alternative Systems for Small Communities and Rural Areas"

Sewage bacteria break up some solids in tank. Heavy solids sink to bottom as sludge. Grease & light particles float to top as scum. Liquid flows from tank through closed pipe and distribution box to perforated pipes in trenches; flows through surrounding crushed rocks or gravel and soil to ground water (underground water). Bacteria & oxygen in soil help purify liquid. Tank sludge & scum are pumped out periodically. Most common onsite system. Level ground or moderate slope.


Absorption Field (Trench)
Distribution Box
Septic Tank
Scum
Liquid
Sludge
Unexcavated
Gravel or Crushed Rock

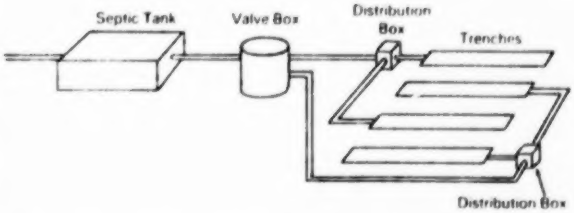
Septic tank and soil absorption field (trench)

(A) Pump or siphon forces liquid to perforated pipes in controlled doses so all pipes discharge liquid almost at same time (dosing). Spreads liquid more evenly & gives field chance to dry out between dosings. (B) Variation of Sketch 1 absorption field. Can be used for dosing & where ground is level or nearly level.


Distribution Box
Absorption Field
Septic Tank
Pump or Siphon
(A)
Closed Loop Absorption Field
(B)

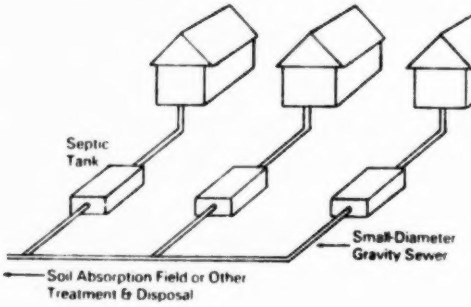
Septic system refinements:
(A) Dosing (B) Closed loop

One field rests while other is in use. Allows field to renew itself. Extends life of field. Provides standby if one field fails. Valve directs sewage liquid to proper field. Fields usually switched every 6-12 months.


Septic Tank
Valve Box
Distribution Box
Trenches
Distribution Box

eptic tank with alternating absorption fields

4"- 6" pipe is sloped so liquid from septic or aerobic tank flows through pipe to treatment & disposal. Treatment & disposal system can be conventional or alternative. Small pipe costs less than conventional 8" pipe.


Septic Tank
Small-Diameter Gravity Sewer
Soil Absorption Field or Other Treatment & Disposal

Small-diameter gravity sewers
(collection system)

Source: USEPA Small Wastewater Systems "Alternative Systems for Small Communities and Rural Areas"

APPENDIX C
WASTEWATER TREATMENT ALTERNATIVES ENGINEERING DESIGN CRITERIA*

System	Design Criteria		
Septic Tank/Soil Absorption Field (Unmodified)	Tank Capacity	flow 750-1500 gal/day - 1.5 times average daily flow	
		flow 1500-15,000 gal/day minus 1.125 + 75% of average daily flow	
		minimum soil depth of 4 ft. to limiting layer	
	Soil Absorption Field	Soil Percolation Min/In	Application Rate gpd/ft^2
		<1	not suitable
		1-5	1.2
		6-15	0.8
		16-30	0.6
		31-60	0.45
		61-120	0.2
Septic Tank/Sand Mound System	Tank Capacity	Min. 900-1000 gal	
	Mound System	0.25 - 1.2 gal/ft^2 24" natural suitable soil below sand	
Septic Tank/Artificially Drained System	Same as soil absorption field, must lower water table to get proper soil depth		
Septic Tank/Evapotranspiration Bed (ET)	Design based on the local annual weather cycle, use 10 year expectancy year to provide sufficient surface area		
Septic Tank/Polishing Surface Discharge	Sandfilter	Buried 0.75 to 1.5 gal/d/ft^2 Intermittant 5 gal/d/ft^2 Recirculating 3 gal/d/ft^2	
Aerobic Treatment Units/Non-Surface Disposal:	Design flow	75 gal/d/person	
	Mixing Requirements	0.5 to 1.0 hp/1000 ft^3	
	Oxygen Requirements	0.2 to 1.0 O_2/hp hr	
	Weir Overflow rates	peak <800 gpd/ft average 200-400 gpd/ft	
	Absorption areas same as soil absorption field		
Aerobic Treatment Units/Surface Disposal:	Design flow	75 gal/d/person	
	Mixing Requirements	0.5 to 1.0 hp/1000 ft^3	
	Oxygen Requirements	0.2 to 1.0 O_2/hp hr	
	Weir Overflow rates	peak <800 gpd/ft	

WASTEWATER TREATMENT ALTERNATIVES ENGINEERING
DESIGN CRITERIA

System	Design Criteria	
	Sand filter	average 200-400 gpd/ft sand size 0.2 to 0.6 mm uniformity coefficient 4.0
Holding Tank	7 days storage at average flow	1000 gal minimum

In House Waste-Water Treatment and Recycle

Reuse Water Quality Criteria

Reuse	Water Quality BOD mg/l	 SS mg/l	 Turbidity TU
Toilet Flushing	20	20	25
Utility Water	15	15	20
Body Contact	10	10	1

System	Design Criteria
Wastewater Segreation	Same total disposal area required, black water can go to the most desirable disposal site.
Options for Handling Blackwater Stream	Dispose as normal septic tank effluent.

Community Soil Absorption System

Hydraulic Loading Rate 0.25-1.2 gpd/ft^2

Soil Percolation Min/In	Application Rate gpd/ft^2
<1	not suitable
1-5	1.2
6-15	0.8
16-30	0.6
31-60	0.45
61-120	0.2

System		Design Criteria
Community Evaporation Infiltration Lagoons		Design flow 50-75 gals/person/day Detention time 7 to 50 days pH 6.5 - 10.5 Temperature Range 0 to 50°C
Multiple Compartment Septic Tank/Soil Absorption Field		Second compartment 1/3 to 1/4 the length of standard septic tank Soil absorption criteria: same as standard septic tank absorption field
Aerated Lagoon/ Spray Irrigation System	Lagoon	Detention time 3 to 10 days Depth 6 to 20 ft pH 6.5 to 8.0 Temp 0 to 40°C (optimum, 20°C) Oxygen requirement 0.7 to 1.4 times BOD removed

WASTEWATER TREATMENT ALTERNATIVES ENGINEERING
DESIGN CRITERIA

System	Design Criteria
	Irrigation Organic Loading 10-300 lb BOD/Ac/D Area 56 to 560 ac/mg/day Application Rate: 2 to 20 ft/yr 0.5 to 4.0 in/wk Soil Depth 2 ft Soil Permeability 0.06 in/hr
Package Plant Surface Water Discharge (extended aeration plant)	Volumetric loading 16 BOD/d/1000ft^3 5 to 10 MLSS, mg/l 3000 to 6000 F/M, 165 BOD/d/lb MLUSS 0.05 to 0.15 Detention time hours 18-36 Std ft^3 air/lb BOD applied 3000 to 4000 Sludge retention time days 20 to 40 Recycle Ratio 0.75 to 1.5 Volatile fraction of MLSS 0.6 to 0.7
Marsh-Pond/Surface Water Discharge	Detention Time 13 days Flow depth 1-5 ft Surface area 8 ac/mg/day
Oxidation Ditch/ Surface Water Discharge	BOD loading 8.6 to 15 lb/1000 ft^3 aeration vol/d Channel depth 4 to 6 fgt Channel shape 45 to 90 degree side walls Detention time 1 day Sludge age 10 to 33 days
Convention Secondary Treatment Plant/Inland Surface Water Discharge	Volumetric loding, 16 BOD/d/1000 ft^3 25-50 Aeration time, hr 4-8 MLSS, mg/l 1500-3000 F/M, 16 BOD/d/lb MLUSS 0.25-0.5 Air Requirements Std ft/lb BOD removed 800-1500 Sludge Retention time, days 5-10
Sludge Storage	Tank floor slope 1:12 Mixing: air diffusion 25 ft^3/min/1000 ft^3 Mechanical 1.0 hp/1000 ft^3
Land Application of Sludge:	Application rates based on N,P,K Disposal: 0.5 to 100 tons/acre Crop Nitrogen Requirements: 5 to 10 tons/acre
Sludge Land Filling/Area Fill:	Sludge, application rates: >20% Solids: 3,000 to 14,000 yd^3/ac >15% Solids: 2000-9000 yd^3/ac
Sludge Land Filling/Sludge Trenching:	Trench Widths: < 10 ft: 1200 to 5600 yd^3/ac 10 ft: 3200 to 14500 yd^3/ac

WASTEWATER TREATMENT ALTERNATIVES ENGINEERING DESIGN CRITERIA

System	Design Criteria
Sludge Lagoons:	Side slopes: exterior 1:2 interior 1:3 Depth of Sludge ft 1.5 - 4.0 Pounds of solids 2.2-2.4 lb solids/yr/ft^3
Co-Incineration	Sludge dewatering 20-30% solids
Composting Sludge/ Septic Static Pile	Air Flow 100/ft^3/h/ton of sludge Land requirement 0.3 - 5 c/dry ton
Septage Treatment and Disposal	Lime stabilization

Sludge - percent solids	1	2	3	4
pH=11 Ca(OH)$_2$ dosage mg/l	1400	2500	3700	5200
pH=12 Ca(OH)$_2$ dosage mg/l	2600	4300	5000	9500

*The specific design criteria listed have been extracted from detailed technical descriptions contained in the source document. p. 113.

Source: USEPA. 1980. Design Manual: Onsite Wastewater Treatment and Disposal Systems

APPENDIX D

WASTEWATER MANAGEMENT SYSTEM SELECTION CRITERIA

Source: USEPA. 1980. Design manual: on-site wastewater treatment and disposal systems. p. 22, Table 3-2.

N. C. Dept. of Human Resources, Div. of Health Services, Environmental Health Sec. July 1, 1982. Laws and rules for ground absorption sewage treatment and disposal systems. Section 1900, North Carolina Administrative Code; Title 10, Health Services, Environmental Health; Subchapter 10A, Sanitation. W/October 30, 1982 and January 1, 1983 Amendments.

USEPA. October 1977. Alternatives for small wastewater treatment systems--on-site disposal/septage treatment and disposal.

Table 1. Criteria for Determining the Suitability of Sites for on-Lot Subsurface Soil Absorption Systems on Barrier Islands

Site Parameter	Suitable	Provisionally Suitable Only with Modifications to System	Unsuitable
I. Soil Character			
A. Texture - refers to the relative proportion of the various sizes of solid particles in the soil that are smaller than 2 mm in diameter.	Sandy and coarse loamy soils. Clayey soils with blocky soil structure.	Fine loamy soils. Clayey soils with blocky soil structure.	Deep clayey soils. Organic soils.
B. Structure - refers to the aggregation of soil particles into clusters of particles, called peds, that are separated by surfaces of weakness which open planar pores between the peds.	Sandy and coarse loamy soil structures.	Blocky soil structure in fine loamy and clayey soils.	Platey soil structure in clayey and fine loamy soils. Massive (absence of structure).
C. Depth	Greater than 48 inches.	Less than 48 inches and greater than 36 inches. Less than 36 inches where modifications of conventional system can be made.	Less than 36 inches for conventional systems. Less than 12 inches for certain modified systems.
D. Restrictive horizon - bedrock, iron pans (plinthite) and cemented iron-aluminum - organic hard pan (such as organic mucks and peats).	Greater than 48 inches below ground surface (ideal situation is when it is greater than 72 inches).	Between 36 and 48 inches. Less than 48 inches maybe suitable for use by modified conventional, pressure, or mound systemss.	Less than 36 inches below the ground surface. Less than 12 inches for certain modified system.
E. Drainage - soils with seasonally high water table; indicated by color and color patterns in the soil.	Subsurface Soil colors of reds, yellows, and browns.	Grayish soils with suitable texture and structure and modified to keep groundwater at least 12 inches below the trench bottom of subsurface disposal system.	Grayish soil profiles of chroma 2 or less within 12 inches of the ground surface.
F. Filtering Capacity - treatment ability		Soils underlain by loose sand and gravel or fractured bedrock at a depth less than 4 feet below the distribution lines.	
II. Topography			
A. Slope of hills and pattern of terrain.	uniform slopes under 15 percent	Uniform slopes between 15 percent and 30 percent if soils are deep (greater than 36 inches). Uniform slopes greater than 30 percent if a thorough study of the soil shows the following:	Slopes greater than 30 percent (rarely present on barrier islands). Complex slope patterns and slopes dissected by gullies and ravines.

Table 1. Continued

Site Parameter	Suitable	Provisionally Suitable Only with Modifications to System	Unsuitable
		(1) Slope can be terraced or graded to maintain a minimum 10 foot horizontal distance from bottom of subsurface disposal system lines and the ground surface. (2) Soils classified as suitable or provisionally suitable. (3) Surface water runoff is diverted. (4) Groundwater is intercepted and diverted, if necessary. (5) Sufficient ground area is available for modifications.	
III. Groundwater			
A. Seasonal high water table level.	Greater than 48 inches below ground surface.	Less than 48 inches below ground surface but greater than 36 inches for conventional systems. Between 36 and 12 inches below ground surface for modified systems.	Less than 36 inches below ground surface for conventional systems. In the range 0 to 1 ft. for modified systems.
IV. Flood Susceptibility	None (protected)	Rarely occurring	10-year or less frequency
V. Land Area			
A. Space availability - required space is calculated based on the square footage required for the previously determined application rate.	Area with less than 3 houses per acre. Area to contain at least 1,000 sf of open "green area" per house served or 2,500 sf/1,000 gal. of wastewater/day.	Sites classified as provisionally suitable concerning soils and topography are suitable if there is sufficient available space to accomodate a replacement subsurface disposal field.	Available space insufficient to permit installation and proper functioning of conventional system (based on application rate). Adequate repair space insufficient (some individual lots exempt).
B. Minimum horizontal distance requirements	Private water supply - 100 ft. Community Water Supply - 100 ft. Streams classified as A-II - 50 ft. Water classified as SA - 100 ft.		

Table 1. Continued

Site Parameter	Suitable	Provisionally Suitable Only with Modifications to System	Unsuitable
	Any other lake or impoundment - 50 ft from normal high water line. Any other stream, canal, marsh, or coastal waters - 50 ft. Any Class I or II impounded reservoir used as a source of drinking water - 100 ft. (normal high water line) Any building foundation - 5 ft. Any basement - 15 ft. Any property line - 10 ft. Top of slope of embankments or cuts of 2 ft. or more vertical height - 15 ft. Any water line - 10 ft. Any swimming pool - 5 ft. Any other nitrification field - 20 ft. Interceptor drains - 10 ft. upslope and 25 ft. downslope. Groundwater lowering and surface drainage ditches - 25 ft.		
VI. Loading Rate	Flows not exceeding 1.2 gallons per square foot of trench bottom.	Flows greater than 1.2 gallons per square foot of trench if data from soil study indicate that the high rate is justified.	

Table 2. Individual On-Site Treatment/Disposal Systems

System	Advantages	Disadvantages	Modifications	Constraints
Septic Tank/Soil Absorption Field Wastewater is discharged to a water-tight container in which it is retained to allow solids to settle and partially decompose by anaerobic bacterial action. Clarified effluent is conveyed by gravity in a closed pipe to a distribution box from which it flows by gravity or dosing to perforated pipes in the absorption field. Effluent flows from the pipes through the surrounding crushed rock or gravel to the soil to be absorbed by unsaturated particles. Soil absorption field may consist of a bed or trenches.	(1) Relatively low construction costs. (2) Minimum operation and maintenance requirements. (3) Generally no mechanical moving parts or power requirements. (4) Bacteria and oxygen in the soil help purify the tank effluent.	(1) Poor quality clarified effluent from tank. (2) Septic tank must be pumped every two to three years to remove accumulated sludge and scum. (3) Trenches subject to solids clogging. (4) Large land area requirements based on effluent application rate to absorption system. Best suited for sites with three or less houses per acre.	(1) Two compartment septic tank with baffle wall or partition 2/3 to 3/4 the distance from the inlet. This enhances the tank's clarification capabilities (2) Alternating absorption fields to allow field to renew itself and extend its life. Also provides a standby if one field fails. Fields usually switched every 6 to 12 months (3) V-ditch (V-shaped trenches) to maximize the ratio of sidewalls to bottom area and minimize depth requirements. (4) Low pressure pipe system for uniform distribution of effluent in the field. (5) Serial distribution for sloping fields (contoured absorption field with drop boxes).	(1) Slopes should not be in excess of 5 percent and depressions should be avoided. (2) Minimum horizontal separation distance requirements: Water supply wells, 100 feet; Surface waters, 50-100 feet; Escarpments, manmade cuts, 15 feet; Boundary of property 10 feet; Building foundations, 15 feet. (3) Seasonal high groundwater level and restrictive horizons must be at least 3 feet below the ground surface.
Septic Tank/Mound System Clarified effluent from the septic tank is pumped or siphoned to a mound constructed on the natural soil surface with imported moderate to fine featured sands or loams at a depth of 1 to 2 feet. On top of the filter material the pipe distribution network is constructed within a gravel bed. A protective	(1) Provides a zone of treatment above the natural soil and the underlying restrictive horizon. Purification is achieved as effluent moves through the mound and is lost by evapotranspiration and soil percolation. (2) Can be used where soil conditions are not suitable for conventional absorption	(1) Poor quality clarified effluent from tank (2) Septic tank must be pumped every two to three years to remove accumulated sludge and scum. (3) Relatively high construction costs and maintenance costs. (4) Usually requires pumping. (5) More difficult to construct than conventional	(1) Septic renovation levy is the name applied to system in which the effluent is pumped into the top of the mound in controlled doses through small diameter perforated pipes. (2) Two compartment septic tank.	(1) Slopes should not be in excess of 12 percent and depressions should be avoided. (2) Minimum horizontal separation distance requirements are the same as those for conventional absorption fields except that distance from building foundations should be 30 feet when

Table 2. Continued

System	Advantages	Disadvantages	Modifications	Constraints
Septic Tank/Mound System (continued) covering of fine textured soil is also placed over the mound and seeded for runoff control.	fields such as slow or rapid permeable soils, shallow permeable soils over creviced or porous bedrock, and permeable soils with high water table. (3) Allows development of restricted lot sizes.	absorption field (6) Visual impact of mound causes aesthetic and possible landscape problems.		located unslope from a building in slowly permeable soils. (3) Seasonal high groundwater level and restrictive horizon must be at least 12 to 36 inches below original soil surface.
Septic Tank/Artificially Drained System Clarified effluent from the septic tank is conveyed to a soil absorption field for disposal. The water table below the field is artificially lowered to permit effective disposal. Drainage techniques applicable are curtain drains for perched water tables and lateral groundwater flow problems and underdrains for perched water tables and free water tables.	(1) Can be used where high water tables restrict use of conventional soil absorption system	(1) Poor quality clarified effluent from tank (2) Septic tank must be pumped every two to three years to remove accumulated sludge and scum. (3) Relatively high construction costs (4) Drainage units require infrequent cleaning to maintain their effectiveness. (5) When utilizing underdrains, sometimes a network of drains is required. (6) Few on-site installations existing to provide performance records of the drainage techniques. (7) May require a pump discharge of groundwater.	(1) Two compartment septic tank.	(1) Soils to be coarse textured because fine textured soils of slow permeability are impractical for subsurface drainage. (2) Soils that are saturated for prolonged periods, particularly on level sites, are not practical to drain. (3) A separation distance of 10 feet is recommended between the curtain drain and the absorption field downslope. (4) Minimum horizontal separation distance requirements of the absorption field same as these stated for the conventional field previously mentioned.
Septic Tank/Evaporation Lagoons Clarified effluent from the septic tank is conveyed to an open holding facility which	(1) Effectively treats wastewater in areas which have soil conditions not conducive to	(1) Poor quality clarified effluent from tank. (2) Septic tank and lagoon must be pumped every	(1) Evaporation/Infiltration Lagoon omits the use of an impermeable liner so that soil	(1) Local health ordinances may restrict use due to potential health hazard.

Table 2. Continued

System	Advantages	Disadvantages	Modifications	Constraints
depends solely on climatic conditions to effect dissipation (evaporation) of wastewater. The lagoon is lined with an impermeable plastic liner to prevent soil absorption. Provisions may be required to add makeup water to maintain a minimum depth during dry hot seasons.	the utilization of conventional on-site disposal systems or systems using soil absorption. (2) Utilize meterologic and climatological factors for the operation of the lagoon.	two to three years to remove accumulated sludge and scum. (3) Lagoon has potential for odors and health hazards. (4) Large land area requirements and public access restrictions are necessary for the lagoon. (5) Lagoon may adversely affect surrounding property values. (6) Few on-site installations existing to provide performance records of the lagoon system.	permeability can also be incorporated in the disposal of the effluent. Soil should be of slow permeability.	(2) Annual evaporation rates should exceed the annual precipitation. (3) Land area requirements are a major factor.
Septic Tank Polishing/ Surface Discharge Clarified effluent from the septic tank is conveyed to additional treatment processes for polishing. These processes are normally either buried sand filters, intermittent sand filters, or recirculating sand filters that utilize underdrains when applicable. Disinfection units are also incorporated when necessary prior to discharge to surface waters.	(1) Can be used where subsurface disposal systems are not feasible. (2) Relatively small space requirements.	(1) Septic tank must be pumped every two to three years to remove accumulated sludge and scum. (2) Pumping is required for using intermittent and recirculating sand filters and possibly for the discharge outfall. (3) Construction and Operation/Maintenance costs are relatively high. (4) Centralized management, rather than homeowners, are normally required for successful operation (filter surfaces and disinfection equipment requires periodic maintenance). (5) Potential odor problem from filters. (6) Public access may need to be restricted due to potential health hazard.	(1) Disinfection methods available that have proven effective against bacterial and viral pathogens for on-site application include tablet chlorination, iodine crystals, and ultraviolet irradiation (dry feed chlorinators may require mechanical dosage control).	(1) Surface discharge must be permitted by the regulatory agency (state or federal permits). (2) A receiving surface water must be available (fresh or ocean waters). (3) Sampling and monitoring system is required.

Table 2. Continued

System	Advantages	Disadvantages	Modifications	Constraints
Septic Tank Polishing/ Surface Discharge (Cont)		(7) Chlorine disinfection can result in the production of toxic chlorinated organics in final effluent being discharged.		
Aerobic Treatment Units/ Non-Surface Disposal Wastewater is discharged into an aeration chamber where it is aerobically treated by either a suspended growth (activated sludge, using either a batch or flow-through, extended aeration operation) or by a fixed-growth (packed tower, rotating contractor, or submerged media systems) process. Aeration may be provided by natural convection, mechanical aeration, or forced air ventilation. The aeration chamber is followed by a clarification unit (can utilize a septic tank), along with recycling of treated wastewater back to the fixed-media. Treated effluent is discharged either to a soil absorption field, mound system, or a lagoon for final disposal	(1) Aerobic units, when properly operated and maintained, can result in a higher effluent quality than septic tanks and can reduce clogging in coarse (sandy) soils for soil absorption systems. (2) Cleaner effluent also allows for a reduction in soil absorption area requirements, generally a 1/3 reduction. (3) Aerobic treatment units are being produced by more manufacturers as self-contained package plant with various features incorporated into the design to reduce the need for frequent surveillance and thereby avoid some problems associated with operation and maintenance.	(1) Aerobic units are more prone to microbial upsets if not maintained properly. (2) Construction costs and operation/maintenance costs are relatively high. (3) Few on-site installations for individual homes exist to provide performance record of the aerobic units at that scale (4) Power is required to operate aeration equipments and pumps. (5) Sludge generated must be removed from aerobic unit and any clarification units. (6) Aeration equipment can be noisy and mechanical moving parts are subject to failure. (7) Aerobic units require special start-up procedures every time they are shut down due to the microbes that feed on the wastewater. This could be a problem, particularly for seasonal homes.	(1) A primary clarification unit (septic tank or trash trap) can be installed prior to the aerobic chamber to enhance the aerobic treatment process. (2) Ozones oxidation unit can be used as the aerobic unit but this process is still a developing technology and therefore expensive to use.	(1) Aerobic units must have regular, semi-skilled operation and maintenance to ensure proper functionin of moderately complex equipment, and inspections every 2 months. (2) Aerobic units must be readily accessible. (3) The restrictions pertaining to the various disposal systems were mentioned previously for the systems utilizing septic tank treatment and apply here with aerobic treatment units. (4) Power source is essential. (5) Public management required.
Aerobic Treatment Units/ Surface Discharge Biologically treated effluent from the aerobic treatment units	(1) Can be used where subsurface disposal systems are not feasible.	(1) Because the aerobic units are more prone to microbial upsets if not	(1) Disinfection methods available include tablet chlorination,	(1) Surface discharge must be permitted by the regulatory agency

Table 2. Continued

System	Advantages	Disadvantages	Modifications	Constraints
Aerobic Treatment Units/ Surface Discharge (Contd) is conveyed to a pumping chamber where it is pumped through an intermittent sand filter for polishing. Disinfection units are also incorporated when necessary prior to discharge to surface waters.	(2) Filter requirements (surface area, length of loading and resting periods, and maintenance) may be less than those for filters following a septic tank and still be able to maintain the same effluent quality. This is because the greater treatment capabilities of the aerobic units discharge a lower organic loading. (3) Aerobic treatment units are being produced by more manufacturers as self-contained package plants with various features incorporated into the design to reduce the need for frequent surveillance. (4) Relatively small space requirements.	maintained properly, variable quality effluent may be discharged to surface waters. (2) Construction costs and operation/maintenance costs are relatively high. (3) Few on-site installations for individual homes exist to provide performance record of the system at that scale. (4) Power is required to operate aeration equipment and pumps. (5) Sludge generated must be removed from aerobic unit and any clarification unit and filter surfaces must be maintained. (6) Aeration equipment can be noisy and mechanical moving parts are subject to failure. (7) Centralized management, rather than homeowners, is normally required for successful operation. (8) Potential odor problem from filters. (9) Public access may need to be restricted due to potential health hazard. (10) Chlorine disinfection can result in the production of toxic chlorinated organics in final effluent being discharged.	iodine crystals, and ultraviolet irradiation. (2) A primary clarification unit (septic tank or trash trap) can be installed prior to the aerobic chamber to enhance the aerobic treatment process. (3) Buried sand filters or recirculating sand filters can be used in place of the intermittent sand filter.	(state or federal permits). (2) A receiving surface water must available. (3) Sampling and monitoring system is required (4) Power source is essential. (5) Aerobic units must be readily available. (6) System must have regular, semi-skilled operation and maintence to ensure proper functioning of moderately complex equipment.

Table 2. Continued

System	Advantages	Disadvantages	Modifications	Constraints
In-house Wastewater Treatment and Recycle Waste stream from one or more household fixtures (graywater sources) are treated to provide the water supply for another use of specific water quality, such as flushing toilets and watering lawns. Treatment methods for recycle include ion exchange, aeration, absorption, clarification, filtration, and disinfection. A major option consists of a holding tank, filtration devices, a disinfection process, and a pump-pressure tank combination for supplying the treated water.	(1) Reduces the quantity of water used and/or wastewater generated which is suitable for increasing the life or improving the performance of on-site soil disposal systems.	(1) Involves semi-skilled to skilled labor, depending on system. (2) Operation and maintenance should be performed by centralized management personnel to prevent potential health risks. (3) Odors may be generated and water quality may be aesthetically objectionable when system malfunctions. (4) User acceptance may be difficult. (5) Few on-site installations existing to provide performance record.	(1) Recycled water can be dyed in some manner for aesthetic reasons.	(1) Remaining wastewater must still be treated because complete recycle-closed loop expensive to install and maintain.
Wastewater Segregation Waste streams are segregated into two components, blackwater (human excreta and garbage wastes) and graywater (wastewaters generated from fixtures other than toilets such as washing machines and sinks). The blackwater is usually handled by either non-water carriage toilets or the very low flush toilets with containment. The graywater requires treatment prior to disposal because it still contails significant levels of pollutants (pathogens). It is recommended that typical residential wastewater treatment/disposal systems (as listed previously) be used until further field data is available for describing graywater characteristics.	(1) The treatment/disposal system used for graywater is designed as a typical residential system but for a significantly reduced flow volume. (2) Non-water carriage toilets are non-discharging and can be used in areas where conventional treatment/disposal systems are not suitable.	(1) Construction costs are relatively high, particularly if the system is to be installed in a building previously constructed (retrofit). (2) Few on-site installations exist to provide performance record. (3) User acceptance may be difficult.	(1) Graywater streams may be handled by a community or regionalized system rather than on-site. (2) Four major options are available to handle blackwater streams. These are further described below.	(1) Two separate systems must be maintained to handle both graywater and blackwater streams.

Table 2. Continued

System	Advantages	Disadvantages	Modifications	Constraints
Options for Handling Blackwater Streams:				
(1) Recycling Oil Flush Toilet. A chemical fluid, generally mineral oil, is substituted for water as the flushing medium. Wastes and oil are separated by gravity in a storage tank. Oil is screened, filtered, and chlorinated before recycle. Typical residential system uses 20-30 gallons of oil. Storage tanks are placed under the house in basement or excavated areas. Periodic maintenance consists of annual dumping of solid wastes, addition of chlorine, addition of oil to maintain proper levels and replacement of oil filters.		(1) Possible problems with odors in dirty oil and disposal of residuals due to their oily character. (2) Relatively high operation and maintenance costs. (3) Systems are complex; efficient operation may be beyond capability of homeowner. (4) Mechanical equipment is subject to failure.		(1) Requires separate plumbing for toilet fixture and large area. (2) Needs a constant power supply.
(2) Incinerator Toilet. Small self-contained units which volatilize the organic components of blackwater and evaporate the liquids. Utilize electricity, natural gas or propane gas, or oil to incinerate the human wastes. Incineration cycle completed in 15-20 min. Exhaust fumes removed by vertical	(1) Solid wastes to be disposed are negligible in volume.	(1) High energy consumption. (2) More frequent maintenance of oil and gas fired than electric. (3) Potential odor, noise, and air pollution problem. (4) Relatively high operation and maintenance costs. (5) Systems are complex and subject to mechanical failure.		(1) Needs a constant power supply. (2) Set usage capacity to avoid overloading, less than 3 uses per hour. (3) Must treat graywater.

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Table 2. Continued

System	Advantages	Disadvantages	Modifications	Constraints
vent and blower. Periodic maintenance consists of cleaning of the waste pan to remove inorganic ash (once a week), replacement of liners (electric only), and semi-annual cleaning and adjustment of burning assembly and/or heating elements.				
(3) Composting Toilet. Self-contained unit where wastes are transported by gravity or screw conveyers to ventilated fiberglass or polystyrene tanks Unit utilizes aerobic biological activity to stabilize wastes. Aerobic composting is for a period of 1 year to produce humus suitable for fertilizer. Maintenance includes periodic removal of composted humus (large unit, once per year and small unit, 4 times per year) and periodic maintenance of mechanical parts.	(1) Simple, low maintenance system. (2) Produces usable compost fertilizer.	(1) Possible odor problem and health hazard. (2) Possible problem with accumulation of flies that may require application of insecticide (must be careful not to harm necessary microorganisms). (3) May require separate waste disposal facilities for liquids.	(1) Can install either small (non-separated) units servicing one toilet to be placed entirely within the bathroom or a larger (separated) unit servicing several toilets and garbage chutes to be placed in a basement or excavated area.	(1) Set usage capacity to avoid overloading (small unit, less than 3 persons and large unit, less than 5 persons). (2) Must treat graywater.

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Table 3. Community Collection Systems

System	Advantages	Disadvantages	Modifications	Constraints
Small Diameter Gravity Sewers Wastewater from home is pretreated by individual septic tanks for the removal of solids, then conveyed by 4 to 6 inch pipe that is installed at a slope based on the design carrying load. Flows from each housing unit is then collected and transported to the treatment/disposal system downstream.	(1) Less installation problems compared to conventional gravity sewers. (2) System is not dependent upon moving parts. (3) Lower operation and maintenance costs than conventional 8-inch gravity sewers. (4) Septic tank settles out some solids and removes some scum, therefore flows to downstream system are less concentrated.	(1) More susceptible to operation and maintenance problems than conventional sewers. (2) Few installations existing to provide performance records. (3) Flows are increased due to infiltration/inflow from the collection system. (4) Sewage being conveyed is septic.	(1) Individual aerobic treatment unit can be used to replace the septic tanks.	(1) Cleanouts must be provided for sewers (large manholes not necessary). (2) Individual septic tanks are required by all users. (3) Must be allowed under state regulations.
Vacuum Sewers Wastewater from home is conveyed to a central vacuum station. A vacuum pump at the station creates a vacuum (at 15-25 inches of mercury) in collector pipe. At wastewater source, a valve opens when sewage presses against it. Sewage is then transported as a slug with a plug of air behind it which forces it through the collector pipes to a tank at the central vacuum station. When sufficient liquid volume accumulates in the tank a central sewage pump is used to transport it to the treatment/disposal system downstream.	(1) Less installation problems compared to conventional gravity sewers. (2) Less growth incurement because of less reserve capacity in sewer lines. (3) Minimal trench draining effect that is associated with sewer pipes in aquifer areas. (4) Deep manholes not necessary. (5) Low construction cost. (6) System doesn't require each user to have a septic tank.	(1) Limited to lift available, therefore more suitable to flat terrain. (2) Have a high cost per unit volume of sewage transported, therefore can be adversely affected by low initial use to design use ratio. (3) High operation and maintenance. (4) Few installations existing to provide performance records. (5) Flows are increased due to infiltration/inflow from the collection system. (6) Difficult to locate system malfunctions.		(1) Valves require yearly inspection. (2) Constant power supply is required for vacuum and sewage pumps. (3) Must be allowed under state regulations.

Table 3. Continued

System	Advantages	Disadvantages	Modifications	Constraints
Pressure Sewer, STEP (Septic Tank Effleunt Pump) Wastewater from home is pretreated by individual septic tanks for the removal of solids. Effluent then flows to a holding tank which houses the pressurization device, control sensors, and valves (normally use small submersible centrifugal pumps). Pump forces effluent through pipe to the treatment/disposal system downstream.	(1) Effectively treats wastewater on individual lots not suitable for on-site disposal (soil absorption fields). (2) Septic tank settles out some solids and removes some scum, therefore flows to downstream system are less concentrated. (3) Limited infiltration/inflow.	(1) Pumping components are more susceptible to operation and maintenance problems. (2) Few installations existing to provide performance records. (3) Septic tanks must be periodically pumped to remove accumulated sludge and scum. (4) Sewage being conveyed is septic.	(1) Cluster system can be incorporated where effluent from several septic tanks flow to one pumping tank. (2) Individual aerobic treatment units can be used to replace the septic tanks.	(1) Constant power supply is required for pumping. (2) Individual septic tanks are required by all users.
Pressure Sewer, GP (Grinder Pump) Wastewater from home flows to a storage tank on-site that houses a grinder pump. This can be installed in the basement of the home to provide easy access for maintenance and greater protection from vandalism. The unit grinds the sewage and pumps it through small-diameter plastic pipe to the treatment/disposal system downstream. It doesn't use a septic tank but any existing tank may be used as an emergency overflow tank.	(1) Effectively treats wastewater on individual lots not suitable for on-site disposal (soil absorption fields). (2) System doesn't require each user to have a septic tank. (3) Limited infiltration/inflow.	(1) Pumping components are more susceptible to operation and maintenance problems. (2) Flows for this system will be more concentrated due to all solids being ground rather than removed from the system.	(1) Cluster system can be incorporated where wastewater flows from several homes are ground and pumped by one unit.	(1) Constant power supply is required for grinder pump unit.

Table 4. Community Treatment/Disposal Systems

System	Advantages	Disadvantages	Modifications	Constraints
Community Soil Absorption System (bed or trenches) Wastewater flows from small diameter gravity sewers or from STEP systems and are transported to a nearby community soil absorption field. Since influent flows to be disposed are very large compared to individual units, dosing/pumping mechanisms are recommended for even distribution.	(1) Septic tank effluent from the individual units doesn't require further treatment. (2) Construction operation and maintenance costs are relatively low. (3) Bacteria and oxygen in the soil help purify the tank effluent.	(1) Land area requirements are very large. (2) Poor quality clarified effluent from individual septic tanks.	(1) Various systems available include: mound system if site has limiting zones such as high groundwater levels. ET or ETA beds if soils soils are not conducive for renovation of wastewaters. (2) Alternating soil absorption fields are highly recommended, particularly a three-field system in which each field contains 50 percent of the required absorption area. This allows the fields to rejuvenate and provides a standby field. (3) Absorption fields could be broken up into a series of smaller trenches or beds to help distribute the effluent over a wider area.	(1) Community soil absorption system requires large land area with soil conditions suitable to allow for proper percolation and absorption. The soil and site constraints listed for individual systems are the same for community systems. (2) Each user must have a septic tank or aerobic treatment unit. (3) Constant power supply is required for dosing/pumping equipment. (4) Bed system requires soils with sandy or coarse loamy texture and 50 percent greater bottom area than trench system.
Community Evaporation and Evaporation/Infiltration Lagoons/Percolation Ponds Wastewater flows from small diameter gravity sewers or from STEP systems and are transported to a nearby community lagoon.	(1) Effectively treats wastewater not conducive to the utilization of conventional soil absorption systems. (2) Utilizes meteorologic and climatologic factors for the operation of lagoon. (3) Construction, operation, and maintenance costs are relatively low.	(1) Additional pretreatment may be required depending on the wastewater characteristics (2) Lagoon must be periodically pumped to remove settled solids. (3) Potential odor problem and health hazard require public access restrictions. (4) Few installations existing to provide operating history. (5) Not demonstrated adequately.		(1) Local health ordinances may restrict use due to potential health hazard. (2) Annual evaporation rate should exceed the annual precipitation. (3) Land area requirements are a major factor.

Table 4. Community Treatment/Disposal Systems

System	Advantages	Disadvantages	Modifications	Constraints
Multiple-Compartment Septic Tank/Soil Absorption Field System can either be two or more individual tanks installed in series or an arrangement where special tank sections are connected together into a unit having single end walls and two compartments (such as a unit of four precast tank sections combined into one tank having two compartments). Effluent from tank is then disposed and conveyed to a soil absorption disposal field. This systems includes a collection system which could be either a vacuum sewer system or a pressure sewer grinder pump system. Also recommended is a dosing/pumping system to provide even distribution of the septic tank effluent on the absorption field.	(1) Construction, operation, and maintenance similar to conventional individual septic tanks and individual soil absorption fields. (2) Relatively low construction and operation/maintenance costs. (3) Effectively treats wastewater on lots not suitable for individual treatment/disposal systems but that are near a site that is suitable and that is large enough to sustain the system.	(1) Design flow must be carefully estimated so system is not overloaded. (2) Commercial wastewaters may require special handling prior to septic tank such as grease removal for restuarant wastewaters and lint removal for laundry wastewaters. (3) Large land area requirements. (4) Failure to be handled by a greater impact than failure of a similar individual system. (5) Flows to be handled by the system may be significantly increased due to the infiltration into the collection system.	(1) Alternating soil absorption systems highly recommended particularly a three-field system in which each field contains 50 percent of the required absorption area. This not only allows the fields to rejuvenate but also provides a standby field (2) Absorption fields should be broken up into a series of smaller trenches or beds because this helps distribute the effluent over much wider areas. A long bed, broken into several shorter systems, each served by a pump or siphon, is preferred over two or more short parallel beds. (3) Utilization of an ET or an ETA disposal system is feasible but requires even larger land area. (4) Utilization of an aerobic treatment system (extended aeration) is well suited to replace septic tank treatment but will require a greater degree of operator attention due to its complexity.	(1) The soil and site constraints for soil absorption disposal system are the same as those for the individual systems listed previously. (2) Single, large area site must be available near the community to be serviced. (3) Constant power supply is required for dosing pumping equipment and for collection/pumping system.

Table 4. Continued

System	Advantages	Disadvantages	Modifications	Constraints
Aerated Lagoon/Spray Irrigation (slow rate) System System includes treatment of collected wastewaters to level required for spray irrigation. Minimum treatment consists of biological treatment by lagoon plus chlorination for fecal coliform control (less than 1000 MPN/100ml).	(1) Higher quality of effluent to be disposed. (2) Areas used as spray irrigation site can be agricultural or forest lands that can be sources of added revenue. (3) Bacteria and oxygen in the soil help purify the effluent while using it to fertilize the vegetation. (4) Effectively treats wastewater on lots not suitable for individual treatment/disposal systems.	(1) Lagoon must be periodically pumped (1 to 5 years) to remove settled solids. (2) Spray irrigation disposal has relatively high construction costs. (3) Potential odor problem and health hazard, therefore system requires a buffer zone and public access restrictions. (4) Land area requirements are very large. (5) Spray irrigation equipment to be operated and maintained by semi-skilled personnel.	(1) Aerated Lagoon can be replaced by a facultative lagoon. This will lower the volume of sludge to be pumped and disposed. (2) Pre-chlorination of wastewaters entering lagoon to increase the efficiency of the lagoon. (3) Land application by rapid infiltration can be utilized in place of irrigation. This method applies lagoon effluent in controlled doses to sandy soil to break down the solids and purify the effluent. It requires less land area but soil must be able to handle large application rates, (rapid permability) and depth to groundwater should be at least 10 feet (lesser depths are acceptable where underdrainage is provided).	(1) Soil conditions must be suitable for land application of treated wastewater effluent. Depth of soil to groundwater should be two to three feet. Soil permability should be moderately slow to moderately rapid. (2) Land area requirements are based on the application rate (which is based on soil conditions) and are a major factor. (3) Slope of land should be less than 20 percent on cultivated land and less than 40 percent on non-cultivated land.
Package Plants/Surface Water Discharge Wastewater flows are collected and conveyed to the package plant for treatment. This plant is a prefabricated (or in easily assembled standard components) unit that normally is designed to handle flows less than 0.050 MGD (1.0 MGD plants	(1) If properly designed, operated and maintained the plant will provide a good quality secondary effluent. (2) Smaller land area requirements than a conventional treatment plant. (3) Smaller hydraulic head	(1) Requires a power source and has high power costs. (2) Requires a skilled operator and has relatively high operation costs. (3) Can have a significant noise pollution problem. (4) Sludge generated must	(1) Plants can be designed as a physical-chemical or a fixed growth system (trickling filters and rotating biological contractors). (2) Plant can be built underground to minimize adverse environmental impacts and susceptibility	(1) Constant power supply is required. (2) Skilled operator is required if a good quality secondary effluent is desired. (3) Surface discharge must be permitted by the regulatory agency (state or federal

Table 4. Continued

System	Advantages	Disadvantages	Modifications	Constraints
are available). Plants are usually biological facilities employing an activated sludge process (extended aeration or contract stabilization) followed by chlorination. The effluent is then discharged into surface waters.	loss than a conventional treatment plant. (4) Fast and relatively low-cost field installations. (5) Reduced excess activated sludge. (6) Generally little or no odor. (7) Relatively low capital costs. (8) Can be used where subsurface disposal systems are not feasible. (9) Effectively treats wastewater on lots not suitable for individual treatment/disposal systems and where land application of treated effluents is not allowed.	be removed. (5) Chemicals may be necessary. (6) Mechanical parts are subject to failure. (7) Very sensitive to large variation in flows.	to storm damage in built-up areas.	permits). (4) A receiving surface water must be available. (5) Sampling and monitoring system is required. (6) Flow equalization is required prior to package plant units.
Marsh-Pond/Surface Water Discharge Wastewater flows are collected and discharged to a closed marsh or pond or combination marsh/pond system. Marsh vegetation assimilates available nutrients and organic contaminants. Pond allows effluent renovation and discharge to surface waters.	(1) Effectively treats wastewater where subsurface disposal systems are not feasible. (2) Relatively low construction, operating, and maintenance costs. (3) Potential habitat for fish and wildlife.	(1) Marsh or pond must be available and nearby or must be constructed. (2) Marsh crop needs harvesting annually. (3) Potential odor and fly problem and may require public access restrictions. (4) Few existing systems to provide performance records.	(1) Surface water discharge could be replaced by land application techniques if site is available and soil conditions suitable.	(1) Local health ordinanaces may restrict use due to potential health hazard. (2) A receiving surface water must be available. (3) Sampling and monitoring system is required.
Oxidation Ditch/Surface Water Discharge Wastewater flows are collected and conveyed to the ditch where they are introduced into a continuous channel, usually an oval, with rotary brushes which	(1) Realtively low construction, operating, and maintenance costs. (2) Easily operated and maintained. (3) Low power requirements.	(1) May require substantial land area. (2) Periodic sludge removal required from ditch. (3) Potential odor and	(1) Conventional activated sludge treatment may be practiced instead of the more common extended aeration process.	(1) Most applicable for wastewater flows between 0.1 and 10 mgd. (2) Requires semi-skilled labor for operation.

Table 4. Continued

System	Advantages	Disadvantages	Modifications	Constraints
aerate the wastewater and move the liquid around the channel. Aerobic micro-organisms suspended in the wastewater metabolize and stabilize organic contaminants. Effluent is then chlorinated prior to surface water discharge. Treatment is actually a simplified form of the activated sludge process.	(4) Can handle, if designed properly, large variations in flow.	fly problems.	(2) "Ell" or "horseshoe" configurations may be constructed to maximize land usage.	

Table 5. Regional Collection System

System	Advantages	Disadvantages	Modifications	Constraints
Gravity Sewers Wastewaters from homes are collected by a larger diameter (greater than 6 Inches) pipe to be transported to downstream treatment/disposal system. Pipes flow due to gravity by proper slope design. Access to a gravity sewer is made by manholes every 300 to 500 feet or at changes in slope or direction.	(1) Oldest and most common wastewater transport system existing. (2) System is not dependent on moving parts such as pumping. (3) System has a long life expectancy. (4) Relatively low operation and maintenance costs.	(1) Relatively high construction costs in rural areas and flat areas where greater depths are required to achieve desired slopes. (2) Possible explosion hazard due to production of gas or improper discharge of combustibles into the system. (3) Flows are increased due to infiltration/inflow from the collection system particularly since conventional gravity sewers have more excess-volume available than small-diameter gravity sewers. (4) Stoppage of flow can occur due to grease, sedimentation, and tree-root development.	(1) Use inverted syphons or lift stations for hilly or excessively flat terrain. (2) Sewers can be sewage only or combined (includes storm runoff) (3) Several different. construction materials available and various construction methods are being utilized.	(1) Deep manholes are required.
Force Mains Wastewaters are conveyed under pressure from the discharge side of a pump or lift station to a point of gravity flow downstream. Wastewaters often first enter a storage well which serves as a suction well for the pump(s).	(1) System has been widely used and fully demonstrated. (2) Involves less land use disruption and construction costs than excessively deep sewering for gravity systems in many areas.	(1) Frequent cleaning and maintenance of force mains is required to remove slimes and solids buildup. (2) Relatively high construction, operation and maintenance costs. (3) Often the dissolved oxygen content of the wastewater is depleted in the storage well and results in a final discharge from the system of septic wastewater which is not only devoid of oxygen but often contains sulfides. (4) Pumping stations are subject to odors.	(1) Various pipe materials are available for use. (2) Mains may be aerated or the wastewater chlorinated to maintain freshness or prevent septicity. (3) Wye cleanouts can be installed on longer lines.	(1) Requires a gravity or pressure system to pick up flows from the individual sources. (2) Constant power supply is required for pumps.

Table 6. Regional Treatment/Disposal Systems

System	Advantages	Disadvantages	Modifications	Constraints
Aerated Lagoon/Spray Irrigation (Slow Rate) System System includes treatment of collected wastewaters to level required for spray irrigation. Minimum treatment consists of biological treatment by lagoon plus chlorination for local coliform control (less than 1000 MPN/100ml).	(1) Areas used as spray irrigation site can be agricultural or forest lands that can be sources of added revenue. (2) Bacteria and oxygen in the soil help purify the effluent while using it to fertilize the vegetation. (3) Effectively treats wastewater on lots not suitable for individual treatment/disposal systems. (4) Low construction, operating, and maintenance costs. (5) Existing installations in North Carolina have had good results.	(1) Lagoon must be periodically pumped (1 to 5 years) to remove settled solids. (2) Potential odor problem and health hazard, therefore system requires a buffer zone and public access restrictions. (3) Land area requirements are very large. (4) Spray irrigation equipment to be operated and maintained by semi-skilled personnel.	(1) Aerated lagoon can be mechanically aerated which would require more maintenance and have higher costs. (2) Aerated lagoon can be replaced by a facultative lagoon. This will lower the volume of sludge generated. (3) Pre-chlorination of wastewaters entering lagoon to increase the efficiency of the lagoon. (4) Lagoon can be divided into at least three cells to increase treatment efficiency. (5) Land application by rapid infiltration can be utilized in place of irrigation as described in the community systems. (6) Aerated lagoon can be replaced by an oxidation ditch.	(1) Soil conditions must be suitable for land application of treated wastewater effluent. Depth of soil to groundwater should be 2 to 3 feet. Soil permeability should be moderately slow to moderately rapid. (2) Land area requirements are based on the application rate (which is based on soil conditions) and are a major factor. (3) Slope of land should be less than 20 percent on cultivated land and less than 40 percent on noncultivated land.
Conventional Secondary Treatment Plant/Inland Surface Water Discharge Wastewaters collected are treated to secondary treatment levels by biological or physical/chemical processes and then chlorinated prior to discharge into a nearby receiving surface water. Advanced treatment may be added when required.	(1) High level of effluent. (2) Effectively treat wastewater where subsurface disposal systems or land application systems are not feasible. (3) Effectively treats wastewater on lots not suitable for individual treatment/disposal systems.	(1) High construction, operation and maintenance costs. (2) Requires a skilled operator. (3) Chemicals may be necessary. (4) Mechanical parts are subject to failure. (5) Sludge generated must be removed. (6) Surface water discharge to inland area may pose a problem.	(1) Conventional Secondary Treatment Systems include biological processes (activated sludge and trickling filters) and physical/chemical processes (sedimentation tanks and chemical precipitation processes).	(1) Constant power supply is required. (2) Skilled operator is required. (3) Surface discharge must be permitted by the regulatory agency (state or federal permits). (4) A receiving surface water must be available. (5) Sampling and monitoring system required.

Table 6. Continued

System	Advantages	Disadvantages	Modifications	Constraints
Conventional Secondary Treatment Plant/Ocean Outfall Wastewaters collected are treated to secondary treatment levels by biological or physical/chemcial processes and then chlorinated prior to discharge via ocean outfall.	(1) High level of effluent. (2) Effectively treats wastewater where surface disposal systems, land application, or surface water discharge (inland) are not feasible. (3) Effectively treats wastewater on lots not suitable for individual treatment/disposal systems.	(1) High construction operation, and maintenance costs particularly for the ocean outfall. (2) Requires a site-specific marginal study for evaluation of the impact the ocean outfall will have on the oceanic environment. (3) Requires a skilled operator. (4) Chemical additions may be necessary. (5) Mechanical parts are subject to failure. (6) Sludge generated must be removed. (7) Few existing installations of ocean outfalls for performance record.	(1) Conventional Secondary Treatment Systems include biological processes (activated sludge and trickling filters) and physical/chemical processes (sedimentation tanks and chemical precipitation processes). (2) Treatment could possibly be reduced to primary sedimentation plus chlorination provided a longer, deeper outfall is utilized and federal regulations relaxed.	(1) Constant power supply is required. (2) Skilled operator is required. (3) Ocean outfall must be permitted by the regualtory agency (state and federal permits). (4) Sampling and monitoring system is required. (5) In order for an ocean outfall to be economically feasible it must serve a substantial population.

Table 7. Sludge/Septage Handling and Disposal Systems

System	Advantages	Disadvantages	Modifications	Constraints
Sludge Storage The rentention and blending of thickened primary and secondary sludge in an open tank to reduce the pathogen population, further stabilize the sludge, equalize short-term peak loads, and to prepare sludge for either further processing or disposal.	(1) Improves capacity of disposal systems.	(1) Potential odor problem. (2) Temporary handling, requires ultimate disposal technique.	(1) Utilization of agitators for mixing. (2) Utilization of recycle for mixing. (3) Utilization of pure oxygen instead of air for aeration and mixing.	
Land Application of Sludge/Septage Liquid sludge, dried sludge and sludge cake are applied to the land by either injection, ridge and furrow spreading or spray irrigation. Consideration should be given to intermediate holding facilities before application to land. Also when utilizing the spray irrigation technique, portable pipes and nozzle guns are preferred to fixed or solid sets.	(1) Ridge and furrow method is well suited for relatively flat land and involves spreading sludge in the furrows and planting non-edible crops on the ridges. (2) Spray irrigation systems require less soil preparation than other methods and can also be used with a wider variety of crops. (3) All methods are relatively simple. (4) Sludge can act as a soil conditioner for agricultural, marginal, or drastically disturbed land.	(1) Land area requirements are large. (2) Equipment with standard tires can cause ruts, compacted soil and crop damage or get stuck in muddy terrain. (3) Potential odor and air pollution problems. (4) Public access to be restricted due to potential health hazard.		(1) Constituent of the sludge may limit the rate of application, the crop that can be grown, or the location of the site. (2) Steep slopes and low lying fields are less suitable. (3) Sampling and monitoring system to be established to guard against surface and groundwater contamination. (4) Spray irrigation necessitates a storage lagoon prior to disposal. Also a screening device at the lagoon's pump suction is mandatory.
Sludge Land Filling-Area Fill (Sanitary Landfills) Sludge is placed above the original earth cover and subsequently covered with soil to achieve stability and soil bearing capacity. Sludge is mixed with a bulking agent, usually soil. Installation of a liner	(1) Suitable when subsurface placement is impossible due to shallow groundwater or bedrock. (2) Area fill mound and dike containment have good land utilization. (3) Dike containment re-	(1) Utilizes large quantities of soil which may require hauling from elsewhere. (2) Stockpiled soil must be kept dry. (3) Few installations. existing for performance' records.	(1) Co-disposal of sludge and refuse.	(1) Provisions must be made for surface drainage control, prevention of gas migration and explosion, dust and vector control, and/or aesthetics. (2) Mandatory installation of a storage lagoon or

Table 7. Continued

System	Advantages	Disadvantages	Modifications	Constraints
Sludge Land Filling-Area Fill (Sanitary Landfills) is generally required for groundwater protection. Area Fill Mound - six foot mounds of sludge/soil mixture followed by 5 feet of soil if additional mounds are placed on top or 3 feet if final soil cover. Area Fill Layer - Consecutive layers of sludge/soil mixture (0.5 to 3 feet thick) with interim cover of soil between layers (0.5 to 1 foot thick). Layering may continue to an indefinite height before final cover is applied Dike Containment - Dikes are constructed on level ground around all four sides of a containment area (steep slope of a hill can be utilized as one dike). Access is provided to the top of the dikes so that haul vehicles can dump sludge directly into containment. Interim soil covers (1-3 feet) can be applied and a final cover (3-5 feet) is applied when fill is discontinued.	quires less soil. (4) Techniques offer better odor and pest control than surface spreading techniques and the likelihood of inadvertent pathogen contamination to humans is greatly reduced.	(4) Area fill layer relatively land intensive. (5) Area fill mound has high manpower and equipment requirements due to the constant need to push and stack slumping mounds. (6) Rainfall causes mounds to slump. (7) Chemicals may be required for odor control. (8) Relatively higher capital costs due to costs of storage facilities and application equipment. (9) Ammonia volatilization is eliminated which reduces any nitrogen-loading safety factor from ammonia loss in surface spreading.		tank. (3) Leachate prevention and control facilities are highly recommended if rainfall exceeds 35 inches per year.
Sludge Landfilling - Sludge Trenching Sludge is placed within a subsurface excavation and covered with soil. Narrow trench-widths less than 10 feet.	(1) Has been fully demonstrated in existing installations. (2) Relatively simple to construct, operate,	(1) Precipitation can cause operating difficulties. (2) Potential soil erosion and odor problems. (3) Narrow trench method is	(1) Co-disposal of sludge and refuse.	(1) Require provisions for control of leachate and gas migration, dust, vectors, and/or aesthetics.

Table 7. Continued

System	Advantages	Disadvantages	Modifications	Constraints
Wide trench-widths greater than 10 feet. Width of trench is determined by the solids content of the sludge.	and maintain. (3) Narrow trench particularly well-suited for smaller communities. (4) Better odor and pest control than surface spreading and the likelihood of inadvertent pathogen contamination to humans is greatly reduced.	relatively more land intensive. (4) Relatively higher capital costs than surface spreading technique. (5) Ammonia volatilization is eliminated which reduces any nitrogen-loading safety factor from ammonia loss is surface spreading.		(2) Soil thickness must be maintained at 2 to 5 feet between trench bottom and seasonal high ground water level or bedrock (or can use a membrane liner and leachate collection/treatment system). (3) Mandatory installation of storage lagoon or tank.
Sludge Lagoons (Septage) Primarily designed to accomplish long-term drying of digested sludge through percolation and evaporation. Requires periodic removal of supernatant. Ultimate disposal of the solids is often as a soil conditioner or land-filling. System usually consists of earthen anaerobic-aerobic sludge digestion cells. Lime addition is suggested to maintain pH between 6.8 and 7.2.	(1) Relatively low construction, operating and maintenance costs. (2) Has been fully demonstrated in existing installations particularly smaller communities.	(1) Large land area requirements. (2) Temporary handling and requires ultimate disposal technique. (3) High potential for odors and insect breeding.	(1) Parallel sets of series lagoons are recommended.	(1) Sludge removal at 1.5 to 3 year intervals. (2) Requires a minimum of 2 cells. (3) Depth to groundwater should not be less than 4 feet.
Incineration Incineration using a combination of sludge and combustible material, other than natural gas or fuel oil, in a single furnace. Techniques include: Fluidized bed furnace Multiple hearth sludge.	(1) Provides a new low cost fuel service for existing sludge disposal facilities. (2) Uses same device to dispose of two waste products thereby being more cost-effective than separate incinerator. (3) Reduces land requirement for disposal. (4) May provide WTP with power.	(1) Requires excess air. (2) Potential air pollution problem due to particulates. (3) Relatively high construction, operation, and maintenance costs.	(1) Separate sludge incineration.	(1) Shredders are required to produce a nominal 1 inch refuse size. (2) Requires continuous power supply.

Table 7. Continued

System	Advantages	Disadvantages	Modifications	Constraints
Composting Sludge/Septage, Static Pile Wastewater sludge is aerobically converted to compost in approximately 8 weeks. Sludge is mixed with a bulking material and placed over porous pipe through which air is drawn and covered for insulation. After about 21 days of aerobic composting it is either dried or cured.	(1) Compost can be used as a low grade fertilizer, a soil amendment, or for land reclamation. (2) Utilizes aerobic metabolism of microbes to degrade sludge.	(1) Drying process is weather dependent (requires at least 2 rainless days). (2) Potential odor problems. (3) Potential human pathogen generation and aerosol distribution dictates careful attention to downwind land use.	(1) Extended high pile, used to save on space and materials. (2) Aerated extended pile, used to save on space and materials. (3) Window method - composting takes place on a surfaced outdoor area and air is supplied by periodic turnings.	(1) In order to use compost, pretreatment of industrial wastes is required. (2) Temperatures must remain above 140°F for composting.
Septage Treatment/Disposal Other methods not yet discussed include lime stabilization, chemical treatment/dewatering, and chlorine oxidation.	(1) Suitable for rural areas where land disposal is not feasible and no STP is available.	(1) High chemical requirements particularly chlorine oxidation.	(1) Disposal at Sewage Treatment Plants.	

APPENDIX E: ON-LOT WASTEWATER TREATMENT AND DISPOSAL SYSTEM SITING CRITERIA

A. R. Rubin, Ph.D., North Carolina Agricultural Extension Service

The following information is excerpted from Section 3.3.2 and Appendix 3.3.2 of the Technical Reference Document, Environmental Inventory Report.

Guidelines for Siting

The purpose of this section of the report is to provide the criteria and guidelines for siting on-site wastewater treatment systems in the Outer Banks of North Carolina. This section of the report draws upon several years of experience with these systems under conditions similar to those experienced in the Outer Banks. The principal investigator for most of this work was B. L. Carlile, Ph.D., North Carolina State University, Soil Science Department, and his colleagues. This portion of the report is not intended to be a comprehensive manual for siting and providing criteria for all soils and site conditions where alternatives could possibly be used. It is intended to provide general siting and guidance criteria.

Laws and rules for ground absorption sewage disposal systems have been interpreted by the North Carolina Department of Human Resources and a set of guidelines exists for determining the suitability of a site for ground absorption of effluent. A variety of site and soil factors are evaluated; based upon these factors, a given piece of property is determined to be suitable, provisionally suitable, or unsuitable for ground absorption sewage disposal systems. The criteria for determining suitability of a site include:

1. topography
2. soil texture
3. soil structure
4. soil depth
5. restrictive horizons (peat layers, seasonal high water table)
6. soil drainage
7. estimated percolation
8. available space

Several alternative systems have been developed which will overcome some of the limitations imposed on a soil body by soil or site properties. These systems include both modifications of conventional septic system practice and alternatives to conventional septic system practice.

The performance of conventional on-site systems may be satisfactory in many areas on the Coastal Plain. Areas where minor modifications to conventional systems may be desirable would include areas with seasonally high water table depth of approximately 24 inches or more. A modification to the conventional septic tank (i.e., a two compartment tank) is recommended throughout all installations in North Carolina.

A two compartment septic tank is an improved version of a standard septic tank. It does enhance solids separation through the use of a slotted baffle wall or partition inside the tank. Ideally the partition is installed at the factory, but it may be installed on the site. It is recommended that this partition be installed between two-thirds and three-fourths of the distance from the inlet of the tank. This baffle has a slit which will allow clarified liquid to flow into the second compartment where additional settling may occur. Settleable solids and floating scum are retained much more efficiently in this system than in a single compartment tank.

A second modification is a V-ditch modification. The V-ditch is a conventional septic tank soil absorption system with a V-shaped rather than a conventional rectangular trench. The purpose of this V-modification is to maximize the ratio of trench sidewall to bottom area and to minimize depth requirements. The V-ditch takes advantage of the fact that effluent infiltrates through sidewalls of the trench rather than through trench bottoms. An additional advantage is that the sidewall can be raked and limed much more easily with the V-modification than with the conventional rectangular modification. Another advantage is that the V-modification is less expensive than conventional rectangular trenches because smaller quantities of gravel must be placed in the trench. It may be installed in areas where soil depth is 24 inches or greater.

A third modification that may be considered is the replacement of highly permeable trench field material with material that is less permeable but has more absorptive sites for effluent treatment. In this system, the highly permeable material is excavated and replaced by the less permeable soils. A sandy loam topsoil would be ideal for this type of application as it would provide many reactive sites for effluent treatment. This type of system would require a natural soil depth of approximately 18 to 24 inches and would rely on either conventional gravity distribution or pressure distribution through the trenches.

Alternative On-Site Systems

Conventional septic tanks consist of a concrete or masonry tank where solids removal and decomposition result in a drain field in which the soil absorbs and treats effluent. Many areas of the coastal zone are not suited for conventional absorption systems due to one of the following conditions:

1. poor drainage
2. impermeable soils
3. high ground water
4. highly permeable soils

The following section summarizes several of the alternatives to conventional on-site systems which may overcome these soils or site limitations. In each alternative the goal is to maximize the sewage treatment capability of a given soil. It is clear that emphasis is placed on providing even distribution of effluent into the soils system. The alternatives listed have been evaluated experimentally at individual homes throughout the coastal zone of North Carolina and, when properly sited, sized, designed, installed, and maintained, will result in no discharge of effluents to surface waters.

Mound System - A mound or septic renovation levy (SRL) is an artificial fill system designed for on-site wastewater treatment and disposal. Waste is pumped into the top of the mound in controlled doses through small diameter perforated pipe. This will insure uniform distribution of effluent into the suitable fill material. Wastewater then moves by gravity through the fill which consists of a mix of topsoil and filter sand. Treatment is achieved by the physical, chemical and biological activity that occurs in the mound. Ultimate disposal of the effluent is achieved by a combination of vertical movement of the effluent into the underlying soil and lateral movement of the effluent both through the mound and over the underlying soil material. Additionally, some effluent is lost through evapotranspiration to the atmosphere.

Mounds can be used to overcome severe site or soil limitations due to shallow soils or high ground water. A minimum depth of 12 inches of suitable soils above a restrictive horizon or high ground water is required for the proper operation of a mound system.

Low Pressure Pipe System - A low pressure pipe system relies on pressure distribution of effluent into a soils system. Effluent is pumped under low pressure (between 2 and 5 psi) through a series of manifolds and laterals. Generally, these manifolds and lateral lines are small diameter PVC pipe placed at shallow depths in narrow trenches in the soil. Ideally the depth of the lateral distribution line is 12 to 15 inches. Since effluent treatment will occur in most soils in 12 inches of soil or less, a minimum soils depth of 24 inches above a restrictive horizon is required for the satisfactory operation of a low pressure pipe wastewater treatment system. A maximum of 6 inches of soil may be added to a soil horizon to yield the 24-inch separation between soil surface and restrictive horizon or water table. In the low pressure pipe wastewater treatment system, effluent is pumped from a pump tank to effluent distribution laterals in controlled doses. This insures uniform distribution of effluent throughout the entire absorption field and provides the most effective utilization of the area. In general, the low presure pipe system is well suited to soils and site limited situations that are somewhat less severe though similar to those that require a mound. These limitations include characteristics such as excessively permeable soils, high water table, or impermeable soils.

Alternatives Analysis

Modified conventional systems and alternative on-site wastewater treatment systems are not a panacea for wastewater treatment and disposal problems that may exist along the Outer Banks of North Carolina. In the Outer Banks as well as in other areas of the state, many lots exist which should not be developed with on-site wastewater treatment and disposal systems. This is due to the fact that neither engineering practice nor operational requirements are amenable to quick solutions. Somewhat of a hierarchy exists for recommending alternative on-site or modified conventional systems. Ideally, conventional systems with their limitied O&M requirements and low initial installation costs would be the first system recommended. If soil and site criteria were such that a conventional system would not adequately function, then a low pressure pipe system would be recommended. Finally, if soil and site conditions are such that a low pressure pipe system would not function adequately, then a mound system would be recommended. In some cases, none of the on-site alternatives mentioned will function adequately. In those cases, the only apparent solution to the wastewater treatment needs is a community collection and treatment system. There are a number of options available for low cost community collection and treatment systems. These might include small diameter gravity sewers, vacuum sewers, or pressure sewers. Each of these options would then treat effluent on a site suitable for land treatment of the waste. This would eliminate discharge of effluent to sensitive environmental areas. A rigid set of site selection criteria and site evaluation criteria must be developed and utilized to insure that conventional systems and alternative on-site wastewater treatment systems function adequately and protect the sensitive environmental areas along the Outer Banks of North Carolina.

Site and Soil Conditions Suitable for Mound Systems

The mound system was adapted to conditions in North Carolina and tested through out the state in an effort to provide a means to overcome soils and/or site limitations which classified lots as unsuitable for either a conventional on-site system or a low pressure alternative system. These conditions include:

1. Somewhat poorly to poorly-drained soils which may exist along the Outer Banks
2. Excessively permeable sands which do exist on the Outer Banks
3. Soils with restrictive horizons, such as a high water table or an organic layer, which may occur at a shallow depth and which also exist along the Outer Banks.

Where these conditions exist, it is unlikely that conventional site modifications such as lot shaping, lot drainage, or community drainage can render a site suitable for absorbing and treating effluent.

The depth of mound fill material required in a mound varies with soil conditions underlying the mound and with depths to seasonal high water table or other restrictive horizons. Stewart (1977) and Stewart and Carlile (1978) indicate that the vertical lengths of unsaturated flow which yields optimum treatment may vary from 12 to 30 inches. This depth is directly related to the textural class of the soil underlying the mound. If, for example, a seasonal high water table exists at a depth of 12 inches from the soil surface and the soils are sandy, then 18 inches of mound fill material would be required to provide a 30-inch treatment zone between the absorption area in the top of the mound and the water table. In clayey soils which may occur along some of the western edges of the Outer Banks, flow paths of 12 to 18 inches are all that is required for mounds to function effectively. A mound system must be designed to match the absorptive and treatment capacities of both the site soil and the fill material utilized in construction of the mound. Often a great deal of disparity exists between the relative treatment capacities of fill material used in a mound and natural soil underlying the mound. In these cases, it is not uncommon to have basal area requirements 4 to 5 times greater than the treatment area requirements. Loading rates for mounds may vary from 0.1 gallon per sq. ft. per day to as much as 0.6 gallon per sq. ft. per day.

Appendix E. Continued

It is necessary to have a minimum of 12 inches of existing natural soil of suitable to provisionally suitable texture, structure and permeability above any restrictive horizons such as high water table or organic layer.

An additional constraint on mounds may be the area requirements. Area requirements as mentioned before are dictated by soil conditions. Table 2 indicates some typical mound dimensions, per 75 gallons flow. In addition to these mound dimensions, septic tanks and pumping tanks must be located on the property at sufficient distances from wells or water lines, and the set backs from the property line boundaries and buildings must all be enforced. Additional information regarding distribution systems of mounds is found in the next section.

Table 2. Typical Mound Dimensions Per 75 Gallons Flow.

Loading Rate (gal/sq.ft./day)	Square Footage of Mound Area
.1	4500
.2	3750
.3	3000
.4	2250
.5	1500
.6	750

Low Pressure Pipe Systems

The LPP system was designed to overcome soils and site conditions which limit or render waste treatment impossible through a conventional soil absorption system. The primary objective of pressure distribution is to provide adequate purification of effluent before that effluent reaches either a perched water table or the true ground water table. Since unsaturated flow of septic tank effluent through a soil of approximately 12 inches (clay and clay loams) to 30 inches (sands) is sufficient to provide adequate treatment, appropriate soil depths are necessary. Obviously, many sites on the Outer Banks will require additional fill material which may be added above the natural soil surface to create the unsaturated flow zone of desired depth. Depth of soils from the soil surface to the seasonal high water table should be between 18 and 24 inches. Depths less than 18 inches to 24 inches will require the addition of fill material. In extremely sandy soils such as those which occur along the frontal dune, depths of as much as 36 inches may be required for pressure distribution systems to be used without additional fill material being required. This is necessary because the sands do not provide the same level of treatment as do the clays and silts.

The components of a pressure distribution system are a conventional septic tank or a two compartment septic tank, a pumping chamber, a submersible pump, a manifold and distribution system of small diameter PVC pipe, and suitable depth of permeable topsoil or topsoil plus fill material above a water table or restrictive soil layer.

Appendix I. Continued

System Design Considerations

The system design must be based upon both the daily wastewater volume to be treated and the natural soil material available on the site. A system must be sized such that it will accept the daily wastewater volume without surface seepage or continual saturated flow conditions underneath the system. The scheme for developing such a system includes:

1. The determination of the daily waste flow,
2. The determination of appropriate soil permeability data,
3. Determination of the dimensions of the system,
4. Design of the pressure distribution system, and
5. Design of the pumping system.

Each of these steps must be addressed by the designer in construction of a low pressure pipe system. Excellent purification of effluent from a low pressure pipe system can be obtained in North Carolina and on the Outer Banks if the system is designed appropriately. In order to accomplish this the system must be:

1. Sized to the required waste flow and loading rate,
2. Placed in the appropriate soil, and
3. Properly constructed, as planned.

As with any soils absorption system, some clogging of the absorptive surface will occur. This will occur even in sandy soils and may reduce the infiltration capacity of the system somewhat. In these highly permeable sands, this is a desired outcome. If the system is properly designed and loaded, such clogging, however, will not reduce the long-term effectiveness of the system. Recommended loading rates for various soils are:

1. Fine to coarse sands 1.2 gallons per square foot per day
2. Sandy loams 0.6 gallons per square foot per day
3. Clay loams 0.5 gallons per square foot per day
4. Clays 0.1 to 0.2 gallons per square foot per day.

These loading rates are contingent upon adequate depth of suitable soils above a water table. These rates should produce some unsaturated flow conditions provide adequate effluent purification and treatment, and minimize any clogging which may result within the fill material.

Distribution System

In order for this system to function successfully, the effluent must be distributed uniformly over the entire surface. This will enhance unsaturated flow conditions through the underlying soil material. The distribution system is the key factor in making a low presure pipe system work effectively. If effluent is concentrated in one area as is typical of a conventional gravity flow system, the effluent moves rapidly through the fill material under saturated conditions and may concentrate at one particular location underneath the system. This one area then becomes overloaded and results in either surface seepage or ground water contamination. Often the remaining part of the conventional system appears dry.

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The primary method by which uniform distribution is obtained is through the use of a pressure system consisting of small diameter pipes connected to a manifold and dosed with a small one-quarter or one-half horsepower submersible effluent pump.

The pumping system is an important component in this process. The pump must be sized such that adequate dosing of the entire system will result before the effluent level in the pump chamber falls below the pump off level. Dosing too frequently will lead to poor treatment of effluent. Ideally, dosing frequencies of 2 to 4 doses per day are optimum. Under ideal circumstances, the volume of effluent discharged per dose should be 4 to 8 times the total pipe volume. This will minimize differences in the volume discharge from orifices while filling the entire network.

Obviously there are a number of considerations which must be addressed during the siting and design of a low pressure pipe system or any other alternative. Because of this each system must be designed and tailored to a specific application. No two alternative systems are exactly the same. This is because of minute differences in soil characteristics or site characteristics. Adequate evaluation of alternative system design is necessary, and local health department officials are required to evaluate design before installation begins.

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